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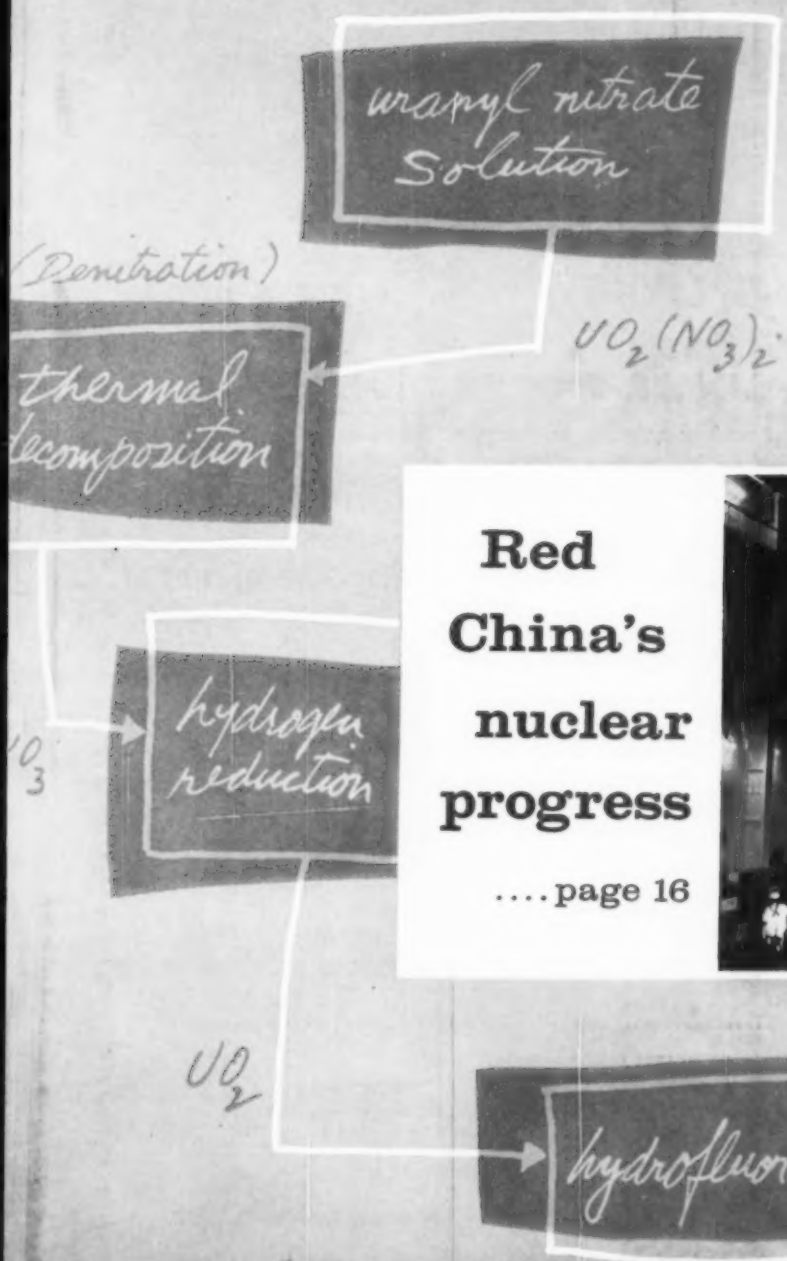
Nuclear engineering

MARCH 1960



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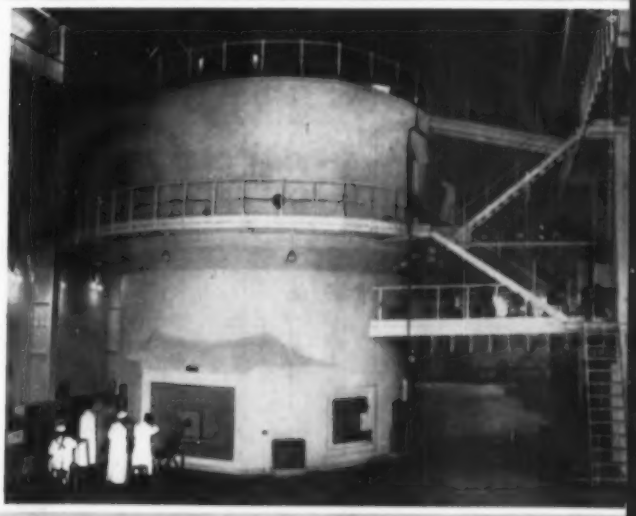

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CHEMICAL ENGINEERING PROGRESS

March 1960 Volume 56, No. 3

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Asst. Publisher L. T. Dupree

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Published monthly by American Institute of Chemical Engineers. Editorial and Advertising Offices, 25 West 45th Street, New York 36, N. Y. Communications should be sent to the Editor. Statements and opinions in *Chemical Engineering Progress* are those of the contributors, and the American Institute of Chemical Engineers assumes no responsibility for them. Subscriptions: U. S. and possessions, one year $6.00; two years $10.00; three years $14.00 (2-yr. and 3-yr. rates apply to U. S. and possessions only.) Canada, $6.50; Pan American Union, $7.50; Other Foreign, $8.00. Single copies of *Chemical Engineering Progress* older than one year cost $1.00 a copy; others are 75 cents. Second class mailing privileges authorized at New York, New York. Copyright 1960 by American Institute of Chemical Engineers. Member of Audit Bureau of Circulations. *Chemical Engineering Progress* is indexed regularly by Engineering Index, Inc.

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Cover by Paul Arlt.

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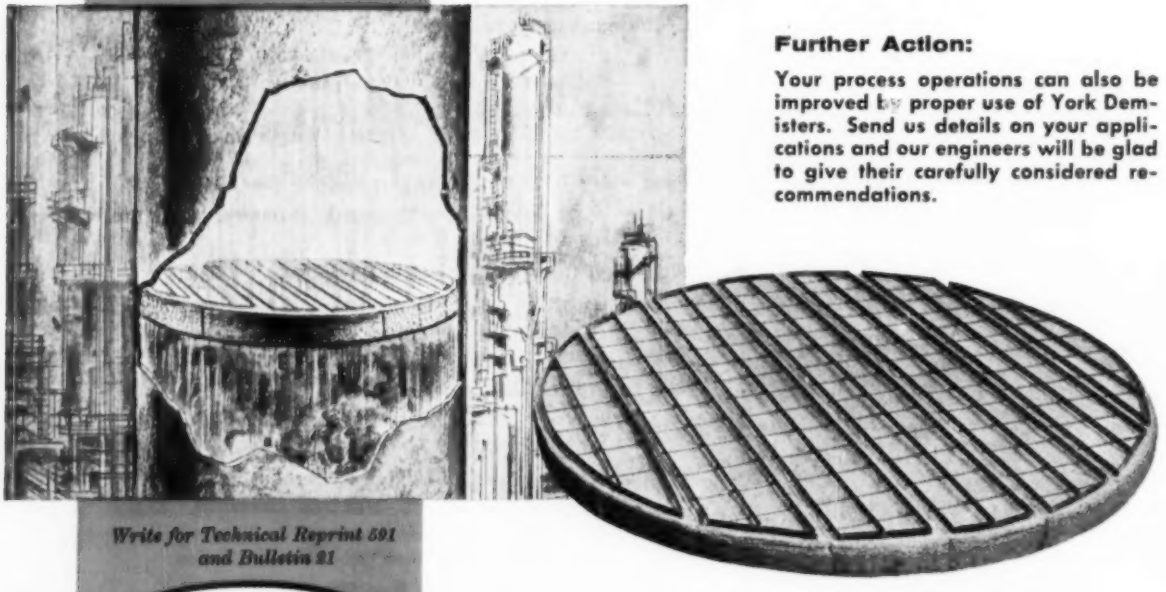

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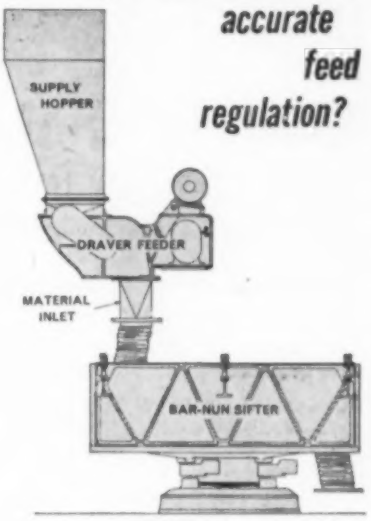

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book reviews

Uranium production and processing in new book

URANIUM PRODUCTION TECHNOLOGY, Ed. by C. D. Harrington and A. E. Ruehle, D. Van Nostrand Company, Inc., New York (1959), 579 + xii pages, $17.50.

Reviewed by John W. Clegg, Battelle Memorial Institute, Columbus, Ohio.

Although not a part of the Geneva Presentation Series of thirteen volumes published in 1958, *Uranium Production Technology* is a companion piece to the series in quality, format, and subject matter. It fills an obvious gap in the coverage of the other volumes in the series.

Presented in eighteen chapters, the book deals with the production of uranium metal and intermediate uranium compounds of nuclear purity from typical mill concentrates (75-80% U_3O_8). It begins with a general introduction to the subject, containing brief but adequate accounts of the history of uranium, its occurrence in nature, its properties, and its uses. Next is an excellent chapter on the "Chemistry of Uranium Processing". Author Kuhlman has performed well the difficult chore of choosing what to include, and what to leave out, of the whole fund of uranium chemistry. There then follows a chapter each on the chemical-technological steps of ether purification, tributyl phosphate purification, UO_3 production, UO_2 production, UF_4 production, UF_6 production, and production of enriched uranium compounds such as UF_5, UO_2F_2, U_3O_8, etc. Authors Harrington, Philoon, Edwards, and Shepardson have arranged these chapters approximately in parallel order, comprising process description and comparison, descriptions of equipment and techniques, and a discussion of specific problems of contamination or waste. Of interest to process engineers: most of the chapters contain a section on direct process costs—often overlooked in a book of this type.

Seven chapters are devoted to metal production and processing: chapter subjects are reduction and casting, ingot uranium, process physical metallurgy, fabrication by press forging, by primary extrusion, and by rolling, and slug machining. Here authors Harrington and Fellows have written a section on uranium metallurgy comprehensive enough to stand alone as a separate volume. The wealth of illustrations in these chapters is especially helpful.

To round out the picture, there are chapters on "Recent Work in Uranium Technology" and "Health Hazard Control". In the first of these, Ruehle gives a discerning summary of recent developments, and, by inference, a glimpse into the future. In the second, author Caplan tells what the plant designer and operator needs to know about hazard control, including costs.

Although there are credits to eight authors and thirteen contributors, the editors have done a smooth job of blending the material into a composite whole. All the chapters are authoritatively written. The book is a true source book in that each chapter is provided with a liberal list of references to reports of the original work. In all, some 700 references are cited, and three of the metallurgical chapters have additional bibliographies appended to them.

The book is generously illustrated with clear line drawings and many pertinent photographs. A competently prepared index makes it easy for the reader to find his way.

This book presents a considerable body of information that is being made publicly available in unclassified form for the first time. The editors, authors, and the Atomic Energy Commission must all be commended for this accomplishment. Even at $17.50, this book is a must for the shelf of the metallurgist or chemical engineer working in uranium refining and production.

United States Vanadium Company's mill at Uravan, Colorado, which has been doubled in capacity and is the largest of the uranium ore-treatment plants in the Colorado Plateau.

BRIMSTONE—THE STONE THAT BURNS, William Haynes, D. Van Nostrand Co., Inc., Princeton, N. J. (1959), 308 pages, $5.95.

Reviewed by F. J. Van Antwerpen, Secretary, American Institute of Chemical Engineers, New York, N. Y.

Williams Haynes's position as historian of the American chemical process industries, already firmly established by his previous publications (especially his six-volume *History of the American Chemical Industry*), is even further enhanced by the recent publication of this well written history of the sulfur industry. It is an informative book,

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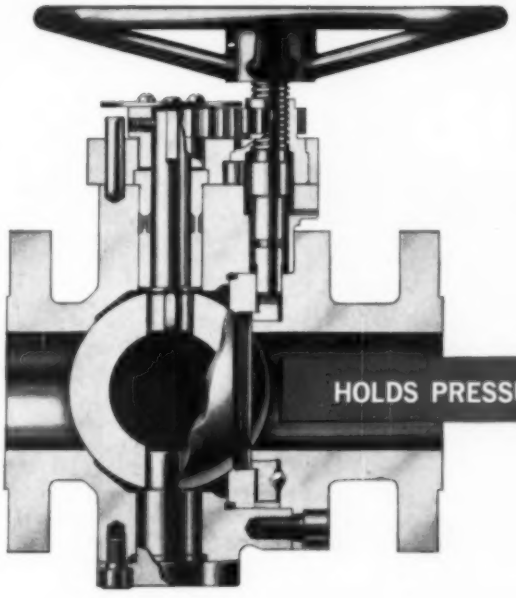

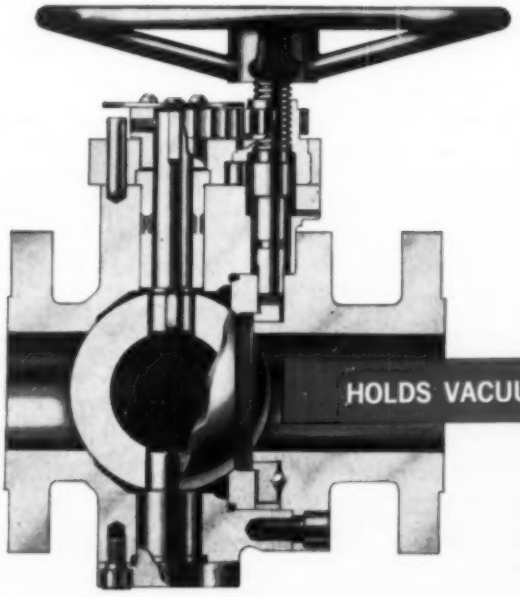

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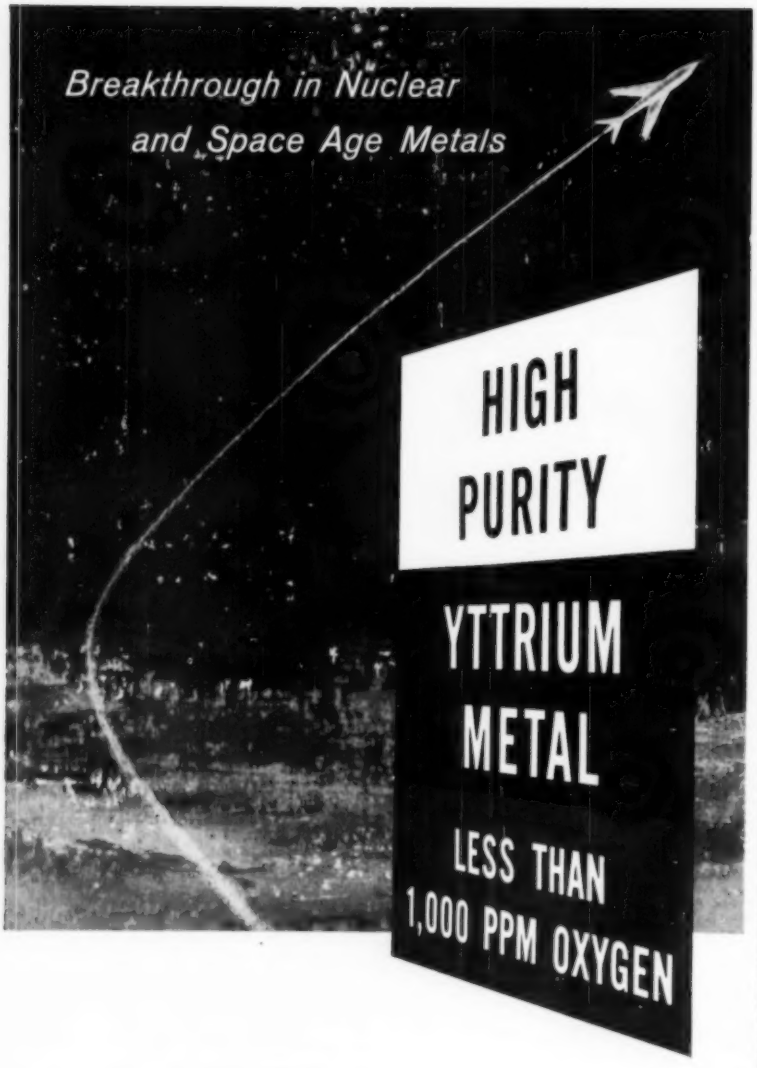

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Book reviews

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one that those in the sulfur industry must read, and that many who have no direct interest in the field will nevertheless find it of great pleasure and value.

The story of the early pioneering days of Herman Frasch, and his drive to prove his process of mining sulfur by pumping hot water underground, is a revealing and touching tale, especially in these days of beehive research and exploration. The book is full of anecdotes, Haynes having the touch that can combine engineering and economic fact with human interest. In Frasch's acceptance speech when he received the Perkin Medal he illustrated the public's dubious reaction to his venture by recalling the remarks of the mail boy who drove him over to the railroad the morning after sulfur was first successfully pumped from the ground. Said the boy, "Well, you pumped sulfur, sure, but nobody believed it but the old carpenter, and they say he's half crazy."

The volume, however, doesn't end with the success of the Frasch process. As a matter of fact, most of the book is taken up with developments since that time. There are chapters on the establishment of the Mexican sulfur industry, the European, the Canadian, etc., plus a chapter on modern technology in sulfur production, and one on the future of sulfur production, with emphasis on the production of sulfur from natural gas.

This is actually the second edition of the book, the first having come out in 1942, and much of the book concentrates on the past fifteen years. It is well illustrated with old as well as modern photographs, and it includes an appendix of statistics on the industry. Notes and references are well documented, and there is a valuable index.

FUELS AND LUBRICANTS, Milosh Popovich and Carl Hering, John Wiley & Sons, Inc. (1959), 312 pages, $8.50.

Reviewed by Dr. W. E. Kuhn, Texaco Inc., Beacon, New York.

The preface states "This book was prepared primarily for use in a college course dealing with fuels and lubricants. However, it should also be of value to men in industry who

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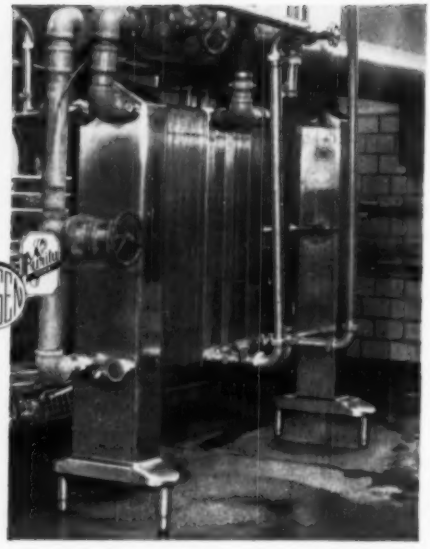

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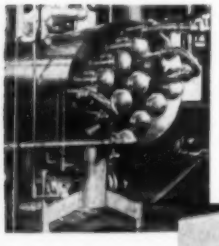

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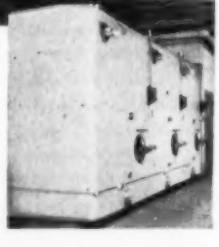

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Book reviews

from page 8

have received no specific training in this field."

The authors have prepared a book meeting this objective. It is a primer for those with mental alertness. The style is easy, simple and straightforward. Of great importance, and to the credit of the authors, they have made their presentations accurate. In many instances an approach such as used in this book results in liberties with accuracy, but this pitfall has been skillfully avoided.

I do not share the slight pessimism intimated in the opening paragraph of Chapter 3 on the future reserves and supplies of petroleum and natural gas.

The chapter on gasoline is one of the best in the book. A complex subject has been highlighted with a great deal of skill. The various properties of fuels, the parameters that relate to performance, and an indication of problems are presented clearly and concisely. The authors are to be congratulated.

The treatment of distillate and residual fuels is good but somewhat of a letdown after the chapter on gasoline.

The chapter on lubricants fails to measure up to the presentation on fuels. Basic significant tests and properties are mentioned, but their significance in relation to performance is not treated effectively. This does not appreciably detract from the treatment when one considers the basic objective of the book. The easy style and accuracy is maintained. The place of synthetic lubricants receives somewhat superficial attention.

The chapter on greases can be considered accurate but elementary.

An effort is made to recognize new techniques such as spectrometry and gas chromatography in use for gas analysis.

The inclusion of a chapter on rocket propellants and energy from nuclear fuels is a real tribute to the foresight of the authors in endeavoring to highlight all phases of fuels and lubricants.

At the end of each chapter references are given. The references, which are identified by number, are more than identification of source of material or data. I would characterize the listings as references and recommended reading. To the student or individual wishing to have more detailed information on any of the

continued on page 12

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One of the largest, most flexible wax manufacturing plants ever constructed has recently been completed by Badger at the Atlantic Refining Company's Philadelphia refinery. The classic and widely used MEK solvent process* was the starting point for this ultra-modern plant. From there, Badger engineers created an unusually versatile design . . . a plant capable of processing eight different feedstocks through fourteen operations to produce corresponding grades of paraffin waxes (oil content 0.2%).

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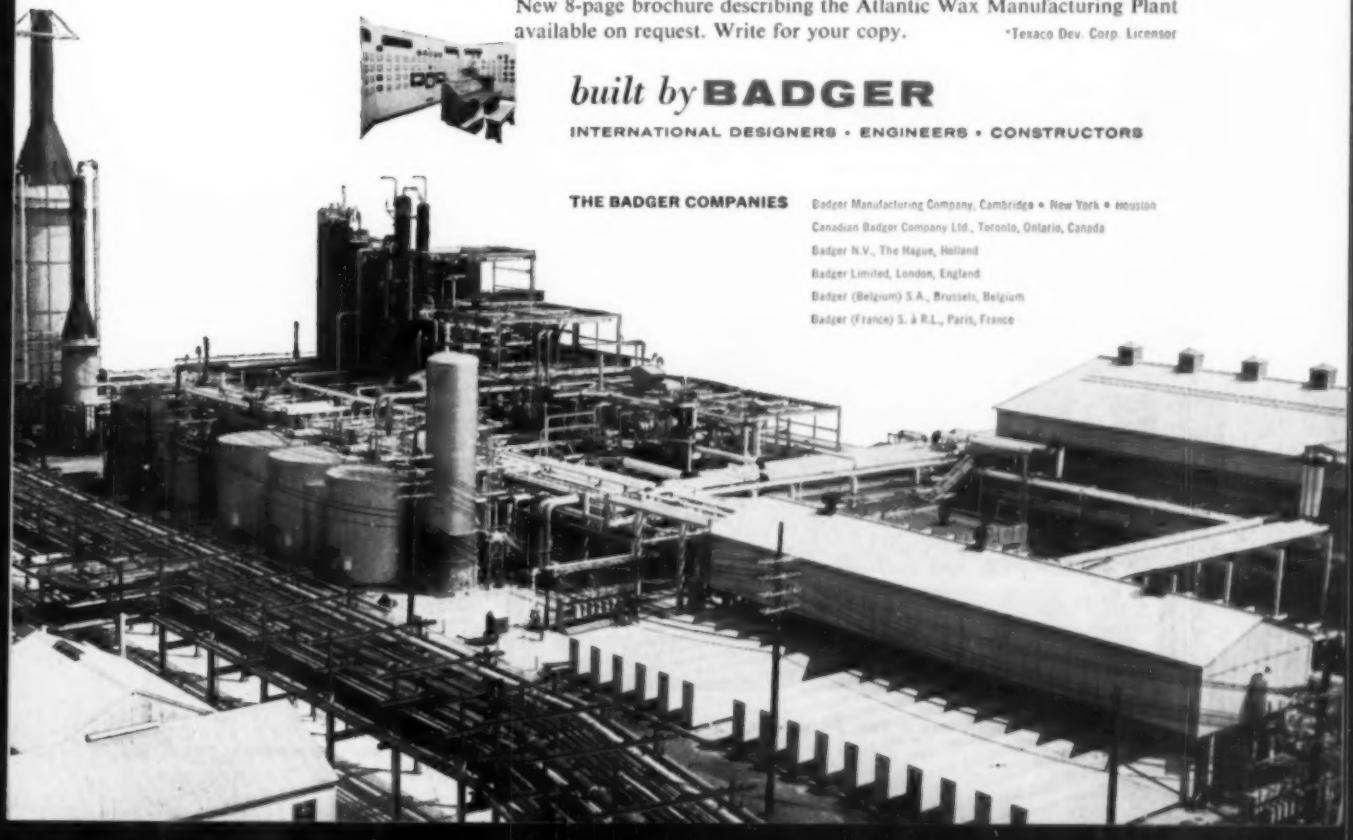

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Book reviews

from page 10

subjects treated, he has in the listing a useful outline of source material. They in turn will supply additional references for even more detailed attention.

The jacket contains a subscript under the title "an accurate and convenient source of information on fuels and lubricants." The book is for college students and "men in industry who have received no specific training in this field." It is not directed to those with experience in the field.

Book Announcements

CHEMISTRY OF NUCLEAR POWER, J. K. Dawson and G. Long, Philosophical Library, Inc., New York, N. Y. (1959), 208 p., $10.00.

DICTIONARY OF ATOMIC TERMINOLOGY, Lore Lettenmeyer, Philosophical Library, Inc., New York, N. Y. (1959), 297 p., $6.00.

HANDBOOK OF CHEMISTRY AND PHYSICS, Charles D. Hodgman, Editor-in-Chief, Chemical Rubber Publishing Company, Cleveland, Ohio (1959), 3472 p.

INSTRUMENTATION IN SCIENTIFIC RESEARCH, Kurt S. Lion, McGraw-Hill Book Company, Inc., New York, N. Y. (1959), 324 p., $9.50.

ORGANIC REACTIONS. VOLUME 10, Roger Adams, Editor-in-Chief, John Wiley & Sons, Inc., New York, N. Y. (1959), 563 p., $12.00.

PROCEEDINGS OF THE FOURTH MIDWESTERN CONFERENCE ON SOLID MECHANICS, The University of Texas, Austin, Texas (1959), 530 p.

PROCEEDINGS OF THE SIXTH MIDWESTERN CONFERENCE ON FLUID MECHANICS, The University of Texas, Austin, Texas (1959), 465 p.

ROCKET PROPULSION, Marcel Barrère, André Jaumotte, B. Fraeijs De Veubek, and J. Vandenkerckhove, Elsevier Publishing Company, New York, N. Y. (1960), 829 p., $27.00.

SOVIET RESEARCH ON THE LANTHANIDE AND ACTINIDE ELEMENTS, 1949-1957, Chemistry Collection Series, Parts I through V, Consultants Bureau, Inc., New York, N. Y. (1959), 662 p., $65.00 the set.

SYNTHESIS AND ORGANIZATION IN THE BACTERIAL CELL, Ernest F. Gale, John Wiley & Sons, Inc., New York, N. Y. (1959), 110 p., $3.50.

continued on page 21

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Atomic progress for 1959

Nuclear process heat, fuel cycle technology, radiation for chemical processing got major emphasis in the 1959 nuclear development program throughout the country.

On the basis of today's technology, says AEC's just-issued 1959 Report to Congress, cost of electric power from nuclear reactors would range from 9 to 13 mills per kilowatt hour. It follows, continues the report, that no reactor plant of 300,000 electrical kilowatts capacity could presently be built in the U. S. to be competitive with a modern conventional power plant of equivalent size in which fuel costs were less than 54 cents per million Btu., a situation prevailing in only a few isolated areas in the country.

Studies indicate that, "under very optimistic conditions," development programs may be expected to bring the cost of power from certain reactor types—light and heavy water reactors, organic-cooled reactors, sodium-cooled reactors, including fast reactors and those moderated with graphite—down to a range of 7 to 8.5 mills per kilowatt hour. At these costs the reactor systems could become competitive with conventional plants using fuel costing from 35 to 40 cents per million Btu., which constitute some 20 to 25% of existing installed capacity of U. S. utility systems.

European pace slows

Continuing flow of oil from the Middle East, accumulating surpluses of coal, the start of exploitation of oil and natural gas in the Sahara, and a mild general slackening in industrial activity, are cited by the AEC Report as factors lessening the urgency for immediate construction of large-scale nuclear power plants in some areas, particularly in Western Europe.

Nuclear process heat soon?

Gasification of coal with high-temperature process heat from a nuclear reactor is the goal of work going on in a joint AEC-Bureau of Mines program at Morgantown, W. Va. Two high-temperature helium loops have been built and operated at about 2,500°F, pressures from atmospheric to 250 lb./sq. in. At the other end of the scale, low-temperature nuclear process heat will be used for conversion of saline water in a cooperative experimental project of AEC and the Department of the Interior at San Diego, California. Reactor will be a 40,000 thermal kilowatt pressurized water type producing saturated steam at pressures from 5 to 175 lb./sq. in.

Fuel cycle development program

During 1959, 24 proposals from 18 private companies were selected by AEC as a basis of contract negotiation for private research and development in its fuel cycle development program. Work under such contracts is expected to cost about $25 million, and to cover a period of from 1 to 3 years. Object: "a substantial reduction in operating costs of power reactors."

Radiation for chemical processing

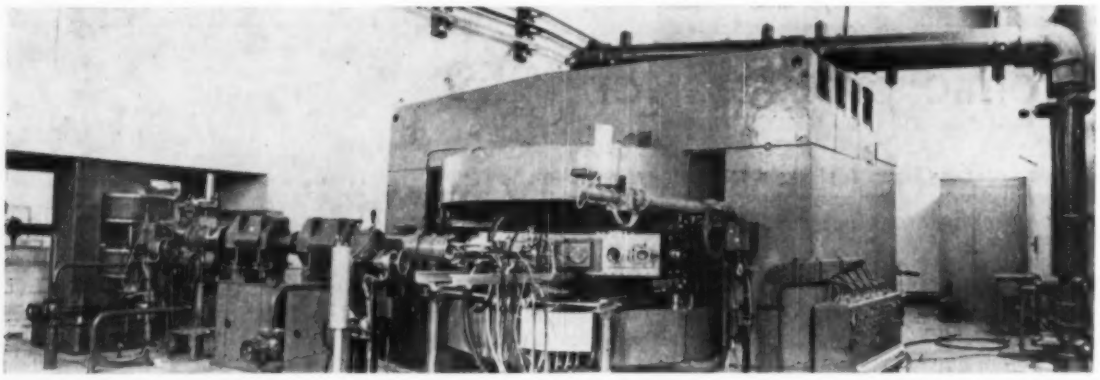
Achievements of the year, says the AEC Report, included a fluorocarbon plastic, produced by irradiation with a Cobalt-60 source, which combines high chemical resistance with an adhesive, bondable surface. Other radiation products now available commercially are a plastic ion exchange membrane with a high efficiency for desalination of brackish water, and an electron beam cross-linked polyethylene film. About 20 contracts were concluded in 1959 for research and development on industrial uses of high-intensity radiation.

U.S. uranium industry overtakes Canadian

U.S. uranium producers in fiscal 1959 doubled their output of two years ago to ship a total of 15,162 tons of uranium oxide, according to figures compiled by Susquehanna Corp., itself a large producer. Canada, in comparison, is reported to have produced about 13,506 tons in 1959.

European chemical construction sparked by Dow, United Carbon

Formation of a new company, Dow Chimica Italiana, and construction of a "multi-million dollar" manufacturing plant in Italy is announced by Dow Chemical International, which has also disclosed plans for a styrene-butadiene latex plant in Rotterdam, The Netherlands. The latex plant will be built and operated by Dow's wholly-owned Dutch subsidiary, Nederlandsche Dow Maatschappij N.V. . . United Carbon will form a French subsidiary to build a $5 million carbon black plant near Rouen in north central France. The facilities are slated for completion in early 1961, will have a rated capacity of 50 million lb./year . . .Also in France a new joint venture to produce para-xylene is being formed by Oronite Chemical, subsidiary of Standard Oil of California, and shareholders of ANTAR Petroles de l'Atlantique, French petroleum firm, and Societe Progil, French chemical company.



China's first cyclotron—at the Atomic Research Institute near Peking, commissioned in September, 1958.

Nuclear progress in Red China

Aid from Soviet Union and Eastern Europe seen as key factor in burgeoning nuclear program behind the Great Wall.

Central control board of China's first atomic reactor at the Atomic Research Institute near Peking. (Note Russian-built instrument panel).

RED CHINA'S FIRST 10,000 kilowatt heavy water type experimental reactor, said to be the biggest in Asia, and a 25-million electron volt cyclotron, both produced with the help of the Soviet Union, have now been in operation about 18 months, according to sources close to Chinese technical circles.

Smaller accelerators of several types, designed and built by Chinese scientists, are also said to be in operation. In addition, many kinds of semi-conductor equipment such as transistors, photoelectric and thermoelectric apparatus have been made. Research work is also being done on new semi-conductor materials. Increasing research is reported to be under way in radio electronics, especially in aspects of pulse and microwave techniques. Microwave measuring instruments, a microwave cyclotron, and a mass spectrograph are said to have been "trial-produced" in China.

Students of the Automation Department of the Chinese University of Science and Technology put together an electronic computer for solution of general differential equations.

Laboratory equipment

Now being made in China are various types of spectrometers and isotope separators, trochotrons, counter tubes, counter telescopes, and nuclear emulsion plates. Other items shown at Peking exhibitions during the last year are said to include: a hundred-channel pulse-height analyzer; a magnetic beam switching tube; a cloud chamber; a milli-microsecond oscilloscope; vacuum pumps with a capacity of 40,000 liters of air per second; a multi-purpose betatron; a universal scaler; and an X-ray fluorescent spectroscope for analysis of rare earth elements. (China claims to

have the world's richest rare earth deposits).

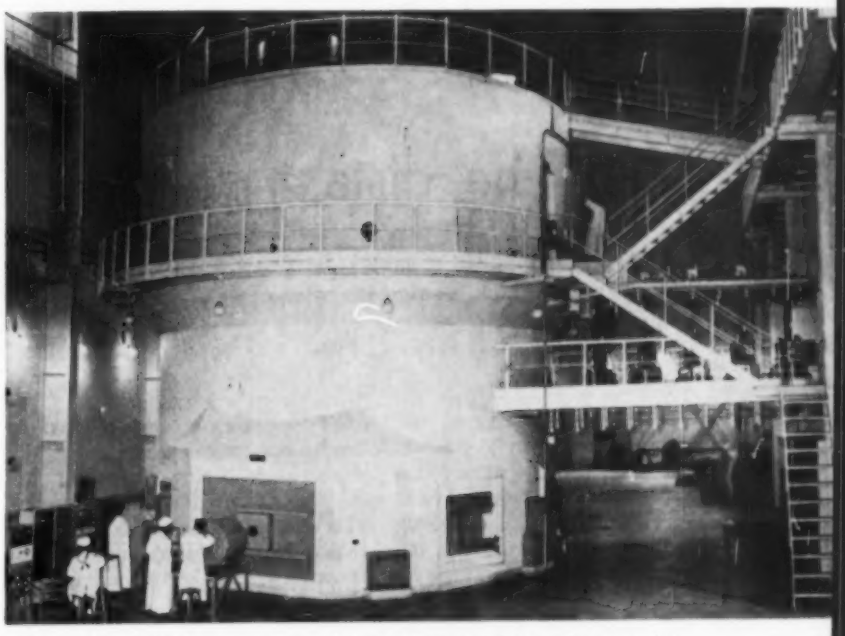
Extent of Sino-Soviet cooperation

Beginning of planned, long-term cooperation between the two countries dates from 1954, when the Sino-Soviet Agreement on Scientific and Technical Cooperation went into effect. A current detailed arrangement is said to provide that, during China's present (second) five-year plan (1958-62), 122 important scientific and technical problems will be studied jointly by Chinese and Soviet scientists, or by Chinese scientists with Soviet aid. There are said to have been something like 300 senior Soviet scientists in China last year.

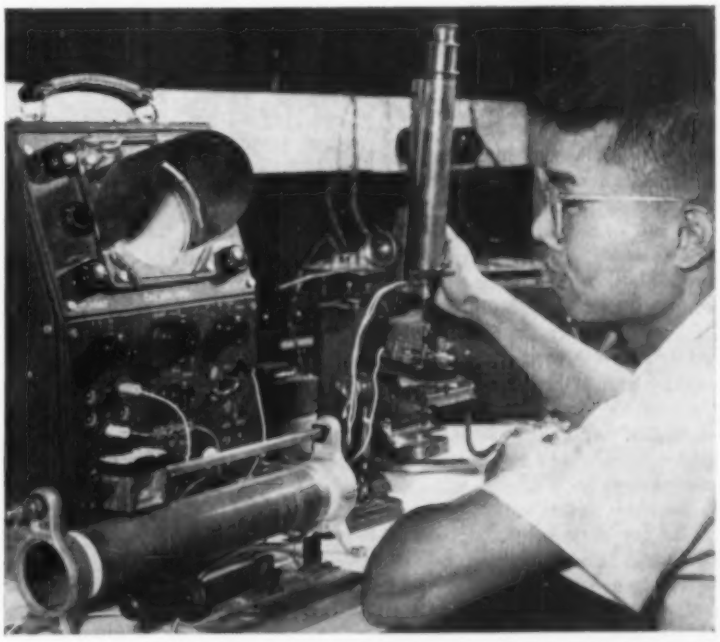
Scientific and technical cooperation has also been increasing between China and the Eastern European countries, both by direct exchanges of personnel and data and through the Scientific Council of the Joint Nuclear Research Institute. The Institute is located in Dubna in the Western Ukraine. The Council of the Institute is reported to consist of 32 physicists from the 12 member Communist countries (Soviet Union, China, Czechoslovakia, Poland, Hungary, Romania, Bulgaria, Albania, East Germany, North Korea, North Viet Nam, and Mongolia). A Chinese nuclear physicist, Wang Kan-chang, is said to be a vice-director of the Institute.

Chinese timetable

Soviet and East European scientists are playing a part in working out China's 12-year plan for the development of science and technology. The plan was launched in 1954 with the aim of making certain that "China will catch up with or approximate the world's advanced levels in the most important branches of science and technology in 12 years" (that is, by 1967). Nieh Jung-chen, a vice-premier of China and head of the Planning Committee for the Development of Science, has since claimed that the 12-year program will, in general, be fulfilled five years ahead of schedule.



China's first 10,000 kilowatt experimental heavy water nuclear reactor.



Hsu Chuan-chih, student at Peking University, physics department, at work in the University's semi-conductor factory. (Factories and workshops have been set up in many parts of China by institutions of higher learning and secondary schools. The instrument shown was made in Czechoslovakia.

Toward the distant goal

Engineering societies urged to take lead in stimulating original long-range basic research, use meetings as sounding board for new ideas.

"THE ENGINEERING SOCIETIES, by providing a much more encouraging environment for papers, discussions, and publications beyond the proven areas, could go a long way in developing a vigorous, enthusiastic advance guard of research people who are reaching into the unknown." So says the committee report of a recent conference on Research Goals sponsored by the National Science Foundation with the cooperation of fifteen scientific and engineering societies including A.I.Ch.E.

Out of the conference came a series of concrete recommendations to the engineering societies:

- Establish "free forums" at engineering society meetings at which any member may make a short presentation of his creative work, allowing the widest latitude of subject matter, with no publication requirement except in abstract form. These presentations, says the committee report, should be handled without critical review by society committees, which "occasionally emasculate original work."
- Encourage presentation and publication of papers of a philosophical nature which look to the future of science and technology.
- Develop comprehensive programs for digesting the "state of the art." Young people, says the report, are often confused by the disorganized state of research knowledge.
- Actively promote and encourage financial support for research. Consider the possibility of the society itself sponsoring research using funds contributed by industry.
- Establish society meetings for the purpose of developing a more effective interchange of ideas between scientists and engineers in research areas of broad mutual interest.

Too much "hole plugging."

Doctoral research should encourage more venturesome attitudes, according to the conference report. The universities can also be guilty of stiffling creative long-range research. The generally accepted requirement that a doctorate student must complete a specified research goal causes students to retreat into "hole-plugging" research. Suggested remedy—"A graduate student who undertakes a long-range project, and who exercises a high degree of originality with persistance and application of effort, should not be penalized by failure to complete the distant objective."

Anti-turbulence research done on porpoise, drag drastically down on dolphins

Flow of liquids through pipes may be accelerated by a new rubber coating, design of which is copied from the ducted, elastic skin structure of porpoises. Claimed to reduce turbulence drag by up to 50 percent, the new coating, developed by Coleman-Kramer, Inc. of Los Angeles in collaboration with U.S. Rubber, will probably find its first practical applications for the outer skins of submarines, torpedos, missiles. Latest design is a thin layer of rubber supported by a multitude of tiny rubber pillars. Inter-connecting channels between the pillars contain a freely flowing viscous liquid. The channels face the surface of the object, while the outside, or liquid side of the coating is smooth. The channels give the coating flexibility, while the liquid provides the damping to suppress potential turbulence.

Visiting foreign scientist program in engineering

Engineers Joint Council will launch a "Visiting foreign scientist program in engineering" soon, under a grant of $25,000 from the National Science Foundation. Purpose—"to broaden the scientific perspective of faculties and graduate students in engineering through interchange of scientific knowledge and research concepts with prominent foreign scientists."

For more information, circle No. 157 ➤

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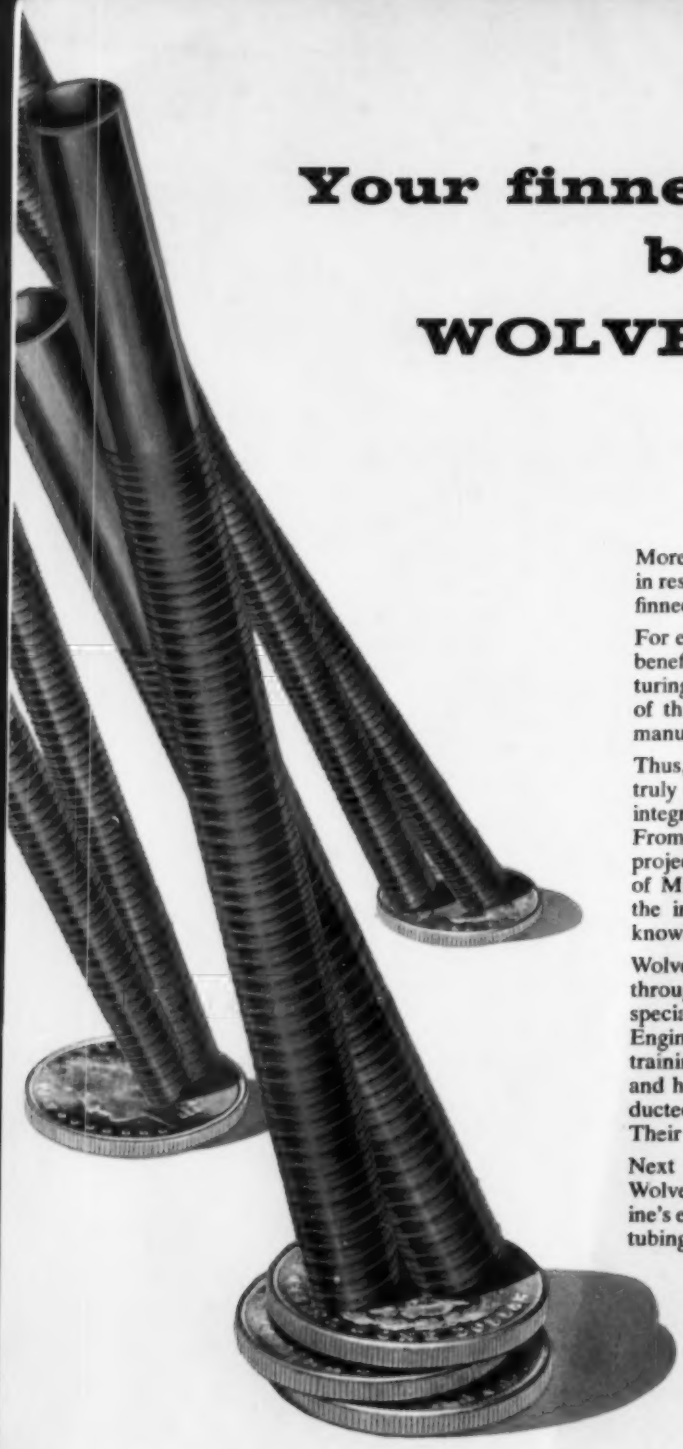

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Wolverine makes this information available to you through its literature and through its staff of heat transfer specialists. These men—members of the Wolverine Field Engineering Service — have all undergone intensive training in finned tube technology in Wolverine plants, and have completed a process heat transfer course conducted by Dr. Donald Q. Kern, Wolverine consultant. Their services are yours at any time—without obligation.

Next time you specify integrally finned tube, consult Wolverine Tube before placing your order. Let Wolverine's experience help you obtain maximum value for your tubing dollars.

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Book reviews

from page 12

SCIENTIFIC RUSSIAN, George E. Condoyannis, John Wiley & Sons, Inc., New York, N. Y., (1959), VIII plus 225 p., $3.50

Reviewed by Leon Jacolev, Technical Director
Associated Technical Services, Inc., Glen Ridge, New Jersey

The post-Sputnick era has been characterized by a lively interest in all things Russian, particularly Russian science and technology. Never before have so many American scientists, engineers, and students in these professions tried to learn Russian through individual or classroom study. It is Mr. Condoyannis's purpose to provide these beginners with "a concise description of the structural elements of scientific and technical Russian" so that "almost from the beginning" they can cope with unsimplified Russian technical material using his book and a dictionary.

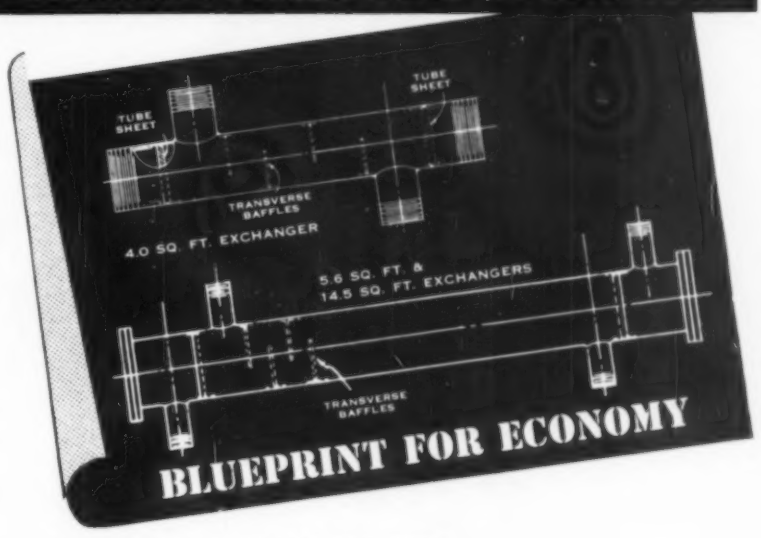
The book is subdivided into 12 lessons that give a birds-eye-view of the structure of the Russian language, grammatical units and patterns encountered in technical prose. Starting with the fourth lesson the student is expected to translate passages selected from Russian monographic and periodical literature. Unfortunately, no translations of the passages are provided by the author, so that the student cannot check the results of his efforts. This is particularly hard on a beginner who attempts to use the book without a tutor.

The organization and presentation of the material is not conventional. For instance, one does not see the complete Russian alphabet till page 10. There is no index, just a table of contents. The case order in declensions is so unusual that even one who knows Russians is nonplussed by the endings till he realizes that the author placed the accusative ahead of the genitive, the prepositional ahead of the dative, and instrumental is chosen to bring up the rear.

It would have been very helpful to the student if the case endings, prefixes, etc., were shown in a distinctive, bold type face. As things are, the text lacks visual emphasis where it is most needed.

Reluctantly, the reviewer must class the book as one that has all the right ingredients, which, unfortunately, were blended into a rather unpalatable dish.

STANDARD Process HEAT EXCHANGERS



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For more information, turn to Data Service card, circle No. 80

letters to the editor

Epoxies on the road

We have read with interest your December Chemical Feature article, "Epoxies for the Tough Jobs" (p. 116) and commend your emphasis on performance rather than "price per pound."

We would, however, like to clarify what appears to be a misunderstanding regarding the use of Epon resins in highways and the equipment required to apply 100% solids coatings using our new Curing Agents H-1 and H-2.

The statement that the cost of cleaning highways will be a deterrent to wider usage of epoxy coatings on roads is not in agreement with experience. Actually, the cost of cleaning a surface prior to the application of an Epon resin coating to highways does not add significantly to the cost of installation. This is especially true in the case of portland cement concrete where acid etching and fresh water flushing with simple, inexpensive equipment frequently costs only a few cents per square yard. The over-all cost of epoxy road coatings will probably limit their use for some time to come to places where protection and skid resistance are required, such as bridge decks and throughway overpasses, toll booths, sharp curves, and airport runways. While we regard skid resistance as an important advantage in Epon resin road coatings, the ability of such coatings to protect pavements from the deleterious effects of freeze-thaw cycling, de-icing salts, and other chemicals encountered in highway use is equally important.

In your discussion of our new Curing Agents H-1 and H-2, you first indicated correctly that these curing agents make possible the application of 100% epoxy coatings "using ordinary spraying equipment . . . ." However, in the next paragraph you go into quite some detail incorrectly stating that "the Shell Chemical technique depends on the use of a special spray gun." We feel that this development will be the answer to many tough maintenance problems in the marine and chemical plant fields. Therefore, we would appreciate your clarifying to your readers, many of whom may be faced with chemical

continued on page 26

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FROM STOCK

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Length	Diameter
18"	1"
30"	1½"
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Length	Diameter
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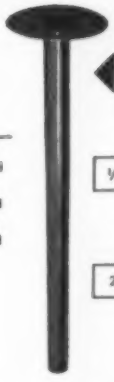

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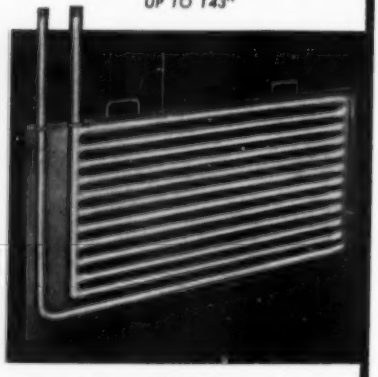

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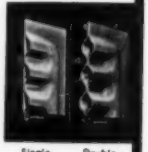

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Washington scope

Economic Boomerang Worries Washington

FOREIGN COMPETITION is a touchy topic in the nation's capitol these days. Almost nobody is willing to be quoted. This is a sure sign that Washington is in for stormy sessions on this subject.

As Senator Clifford P. Case said recently, "The United States is locked with Communism in the greatest economic competition in history. The outcome depends in part on governmental and diplomatic policies and measures. Even more important in the long run is the response of our free enterprise system. Government can and must maintain fiscal and monetary policies conducive to economic growth. It can and must work with other nations, bilaterally and through international agencies, to promote a climate favorable to the international investment and the development of productive enterprise abroad. But government can do only so much. Necessarily, to American business and American labor fall major responsibility for actually doing the job, for demonstrating to the newly emerging nations that economic progress and freedom can go hand in hand."

Just now the chemical industry is beginning to join the battle in a big way. In an effort to hold foreign markets, almost every important U.S. chemical manufacturer has built, is building, or has announced plans to build facilities elsewhere in the free world. Here are recent typical announcements: Vick Chemical has purchased a pharmaceutical concern in Brazil. Firestone Tire & Rubber in a joint venture with Kilachand, Devchand & Company, Private Limited, of Bombay, has announced plans to build a latex plant in Bareilly, Uttar Pradesh, India. Dow Chemical International has announced plans to build a latex plant in Rotterdam, The Netherlands. DuPont, it has been announced, has consummated a 50-50 deal with Showa Denko in Japan, to produce Neoprene.

By building these foreign facilities, U.S. industry is exporting capital and know-how which some feel may, at least in instances, affect our military security. Also we are concurrently exporting jobs which could affect our economic security.

For some years we have, for good cause, been tooling up the rest of the world for efficient production. Senator Case put it nicely: "For the first time in two decades we are faced with real economic competition within the free world. The years when the United States was for the free world virtually the only source of goods and capital are over. Our efforts to rejuvenate Western Europe have been successful. Indeed, some countries, such as Italy, once classified as economically stagnant by economists, are enjoying a new economic vigor. As they have grown stronger, they have heeded increasingly our concern to eliminate trade barriers and to remove discriminations that inhibit international economic growth. Thus, for example, only a few weeks ago the major trading countries of Western Europe acted to make their currencies convertible for international trade. Some trade discriminations remain, but the outlook is good for their gradual removal. . . . Surely the United States will not and cannot seek to withdraw from this new competition which we ourselves have so largely sparked."

The western world has, everyone in Washington agrees, been saved from Communism but, unfortunately, some say the plants built with our money to achieve this result, often have been more efficient than our own and have had a greater capacity than necessary for their home markets. Hence, many foreign chemical producers are looking to the lush U.S. market to absorb the surpluses.

The chemical industry's current defense is to supply capital and know-how to manufacture abroad, ostensibly to sell the output on the foreign markets. But some are yielding to the temptation to sell for hard dollars here in the U.S.A. This government's official attitude on how to meet the competition of low cost foreign production is expressed by Assistant Secretary of Commerce for International Affairs Henry Kearns: "Not only is our nation's economy at this time more dependent upon the world economy than ever before, this dependence is increasing, not diminishing, daily . . . and it is essential that we attain a level of exports which will pay for

these imports as well as make up the difference in other features of the balance of payments in our international transactions." "During the past several months, I have had the opportunity of travelling through Europe, Latin America, and the Near and Far East. As a result of these travels, I have come back to Washington with a sustained confidence in the demand abroad for American products. But I can assure you that this demand will continue only so long as we deliver what the buyer wants and needs under conditions which make the American product competitive in the face of the strongest international competition confronting the United States producer since the early 1930's."

No one will dispute Senator Jacob K. Javits (R-NY) statement: "The critical new issue which confronts us now is the epochal economic struggle between the Communist bloc led by the Soviet Union and the free world led by the United States . . . If the U.S. economic system of a private economy in support of free institutions is to lead the free world to prevail in its struggle for freedom in what is emerging as a decisive economic phase, it will take new measures, new policies and new decisions."

What everyone wants to know specifically is, what are the new measures, the new policies and new decisions that are acceptable to both industry and to the various factions of government. Even the labor unions have accepted the principle that we must accept foreign goods if we are to continue to sell abroad. And they express a willingness to see the U.S. build plants in the underdeveloped countries. However, they want such plants to be designed to produce consumer goods only and to be only of such size as to satisfy the domestic market.

Unfortunately, say some of the experts, the underdeveloped countries usually want the largest and the most efficient plant they can contrive to get. Subsequently, they are tempted to seek hard currency by operating the plant with cheap domestic labor at its peak capacity thereby producing far more than their own domestic market can consume. The surplus they hope to sell for whatever hard currency it will bring. This, they point out, has happened in Europe, and in Asia. Now, they say, it is about to happen in South America. There are indications, according to knowledgeable sources, that the Communists are aggravating the situation by providing additional plants to some countries that already have production capacity far in excess of their domestic needs.

—J. L. Gillman, Jr.

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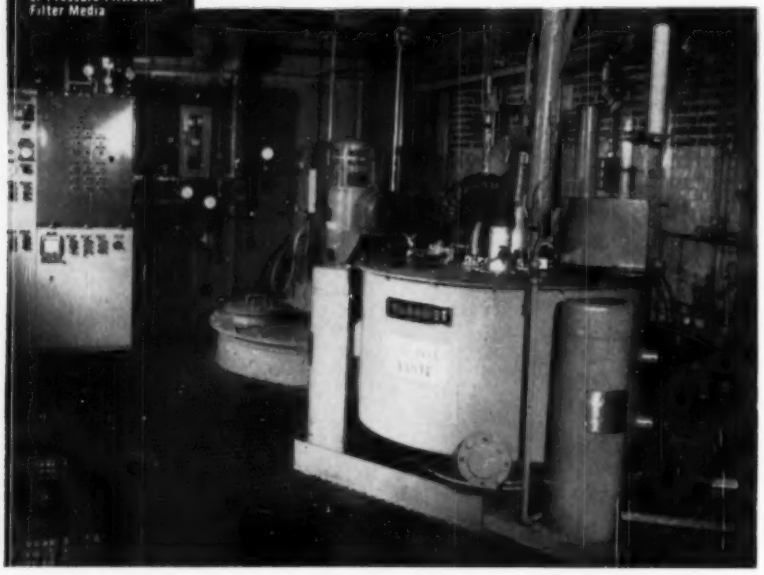

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Letters to the editor

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J. G. DICKERSON, *Manager Sales Development Department*
Plastics and Resins Division
Shell Chemical Co.

"Useless" research?

Your recent article (Opinion and Comment, *CEP*, Nov. 1959) and others (for example, Letter to the Editor by Prof. Sherwood of MIT, *Chem & Eng. News*, April 28, 1959) have pointed out the trend of decline in chemical engineering. However you have not mentioned one of the main reasons for this decline, namely, the lack of inspiring research work in this field.

I often wonder whether many so-called theoretical studies are worth publishing at all. Usually, equations are set up following "recipes" (for example, heat flow must be proportional to the temperature gradient) and solved by computers. The question is "What does the answer mean?" The recipe may or may not be correct. Usually chemical engineering problems involve many parameters (such as film coefficients), and precision of experimental data is poor, so we cannot evaluate these parameters with any confidence. (A recent paper by R. R. White and S. W. Churchill, *A.I.Ch.E. Journal*, 5, 354, Sept. 1959, thoroughly and frankly discussed this point.) Furthermore, these parameters cannot be evaluated either theoretically or experimentally, so these "theoretical" works cannot be useful for equipment design purposes.

One example I might cite is heat transfer between fluids and solids. Here we have film, eddy, turbulent, radial, axial, . . . heat transfer coefficients, most of those parameters have doubtful meaning and certainly cannot be evaluated with any accuracy. Another example is multi-component distillation problems. Here most of the work was done on ideal systems, which are the most exceptional cases. For any non-ideal system, the experimental work required to obtain vapor-liquid composition diagrams is many times more than that required to do the distillation experimentally.

from page 22

(Here more work should be done on predicting multi-component vapor-liquid relations using two-component vapor-liquid data instead of all those fancy mathematics.)

I would like to re-emphasize White and Churchill's opinion: "Do more fundamental work and less fancy-looking but meaningless and useless research."

TUNG TSANG
University of Chicago

Process design information

Often industry asks, "What can we do to help you at the universities to turn out better chemical engineers?" My answer is that industry could help enormously by making available process design and cost information which would be useful in plant and process design instruction. This could include kinetic rate data, design procedures which have been tested by comparison with operating results, and cost data.

A given company's immediate reaction to this proposal might well be that releasing such data could lead to economic ruin. This need not be true. I believe that critical and fundamental design information and procedures could be made available to university chemical engineering departments without jeopardizing the economic position of the individual process company or process design company. Great benefits would result, both for industry and for the universities.

Presently, the design instructor, unless he has had extensive experience in industry and has the "loan" of a company's design manual, must rely on the published literature as his source of rate and design information. It is well known that published data of this kind range from scarce to lacking. But if such information were made available to the instructor he could concentrate on the newer concepts in economic design.

The advantages to industry are equally clear. Graduates would be better prepared to step directly into design positions in smaller companies, and less industry training would be required in the large firms.

With more rate, design and cost information easily available, gradu-

continued on page 28

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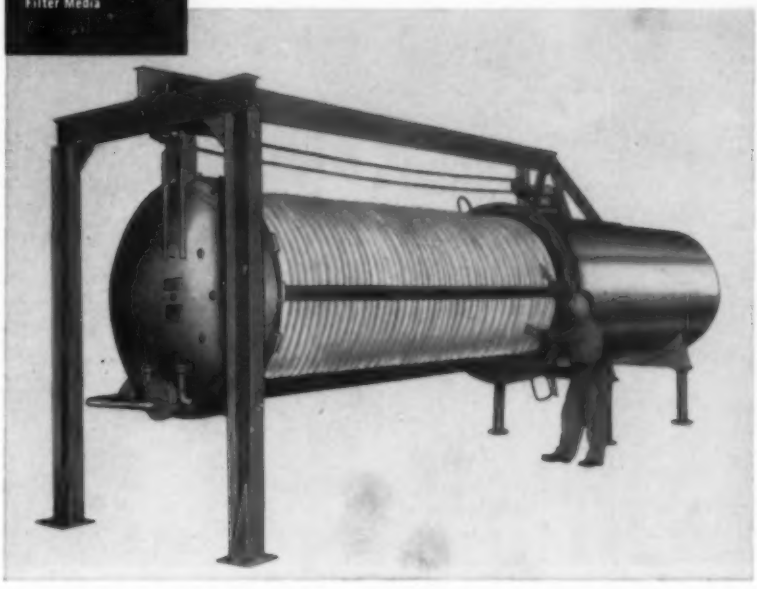

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Letters to the editor

ates would be better prepared in design fundamentals and in new design concepts such as optimization and the use of statistical methods.

A way must be found to surmount the "secrecy" difficulty without putting individual firms at an economic disadvantage. I venture to suggest a possible way to achieve this. Let us divide the processes into three categories: 1) old, well established processes for commodities: 2) relatively new processes now undergoing extensive economically competitive design changes: 3) processes most recently developed.

A great deal of design information on the older processes is lying dormant in company files. More advanced designs have replaced older ones, and the release of the older rate, design and cost information would not produce an economic hardship. Industry has no economic incentive to publish these data in any of the technical or trade journals, but if made available to process design instructors they could introduce much practical stimulus among chemical engineering design students.

The second group of processes seem, too, to offer possibilities. Perhaps when the technology has advanced far enough to provide sufficient protection in the competitive market, the older rate and design information in this category could be released also.

Ordinarily, one could not expect processes in the third category to be made available for design instruction purposes. There is the possibility that rate information on these processes may be available if the work has been done by one of the Government laboratories or sponsored by one of the Government agencies when conditions of secrecy and licensing permit.

Since this concerns the profession as a whole, the work of collecting the information should be carried out within the appropriate committee of the American Institute of Chemical Engineers. No legal problems should be encountered if processes in categories 1 and 2 were offered freely by various companies.

In my opinion, contributing companies will be helping themselves and industry as a whole in the better preparation of the graduates they hire.

GEORGE W. PRECKSHOT
Dept. of Chemical Engineering
University of Minnesota

from page 27

Indexing the literature

In line with your editorial in the December 1959 issue of *Chemical Engineering Progress*, I would like to suggest further emphasis on the field of indexing and making more easily available the rapidly burgeoning field of the chemical engineering literature. I have been following with considerable interest the work being done for the American Society of Metals by the Western Reserve University group on documentation of the metals literature.

It is my understanding that the methods being used by the ASM are not the latest, or perhaps the best, for this purpose. However, I think it is important that this technical society has moved rapidly into a field which needs the kind of attention that only a technical society can do for a whole professional field. We are, of course, always confronted with the immense job done by the American Chemical Society in their chemical abstracts. It seems to me that the Institute could find no better place to expend considerable effort and funds than in an aggressive attack on the problem of documentation of universally available chemical engineering literature. I believe that programs like this and the new machine computation program are needed to make A.I.Ch.E. remain in the forefront during the fabulous '60s.

I feel strongly that re-emphasizing this problem to you might be the best method of seeing that it gets the highest level of attention in the Institute. Let us have more of the new revolutionary, farsighted developments that you cite in your editorials.

R. H. McBride
Engineering Service Division
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A de-sulphurization unit is planned by Koppers at its Follansbee, West Virginia, tar-processing plant. Yearly capacity will be 60 million pounds of virtually sulfur-free naphthalene. This is the company's first commercial installation using the pressure hydrogenation process. First major customer for the plant product will probably be American Cyanamid. They need the low-sulfur naphthalene for production of phthalic anhydride in the fluid bed process at Bridgeville, Pa.

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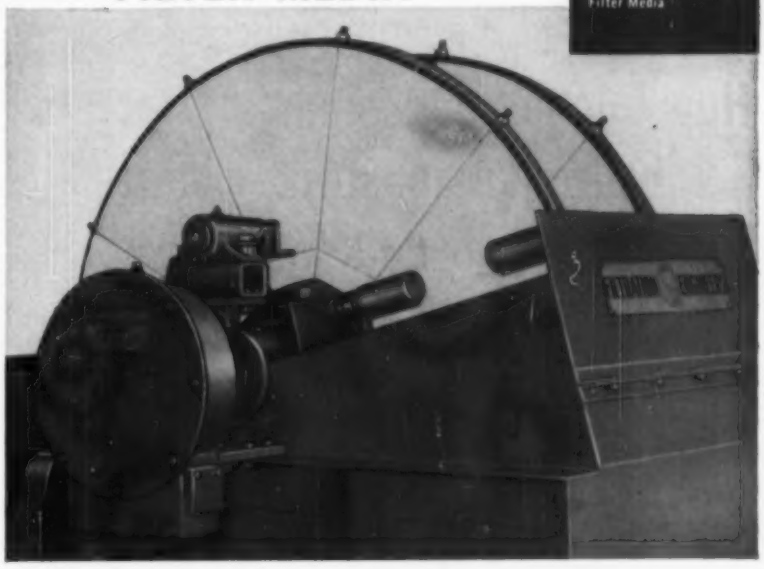

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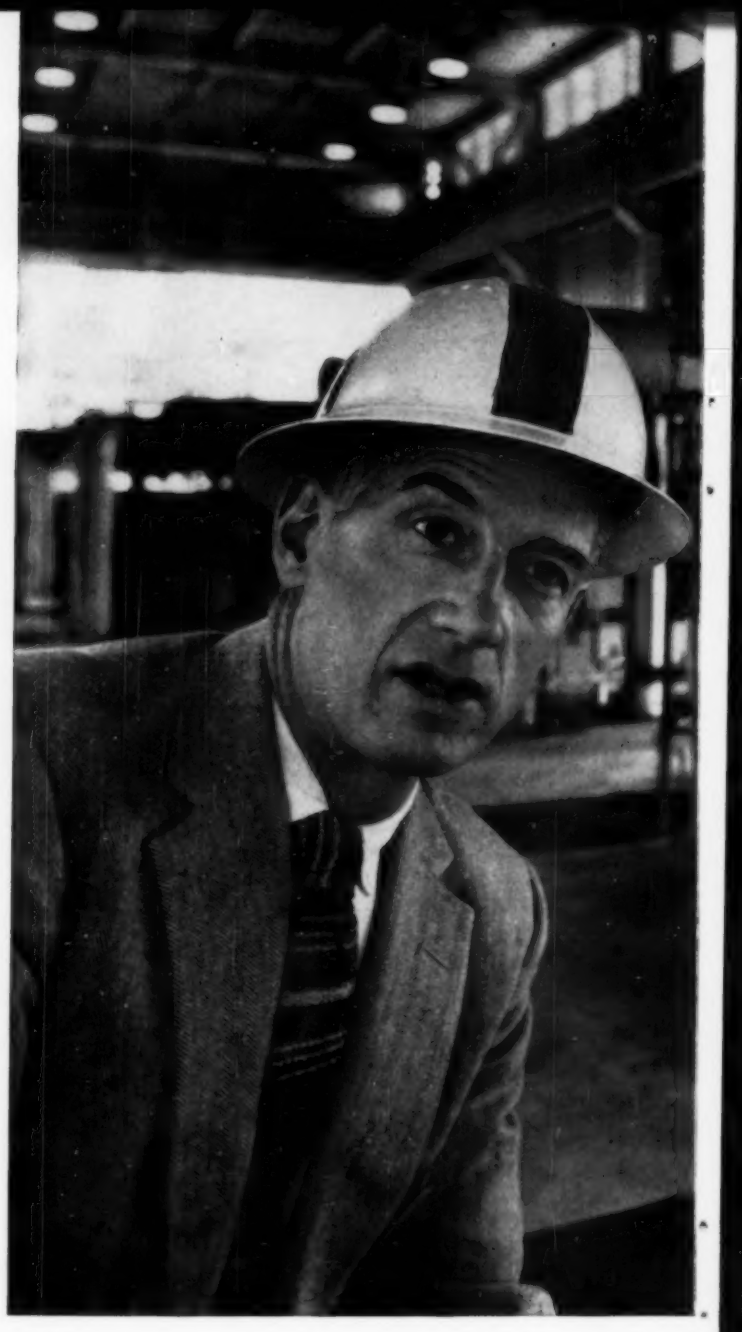
Report from Tidewater...

How Cooper-Bessemer hydrogen boosters supply 800 psi 'round-the-clock



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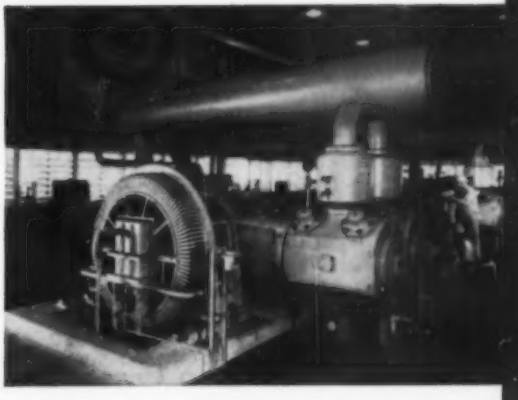
Cooper-Bessemer FM-2 Hydrogen Compressors at Tidewater Refinery. Rated 690 cfm, suction 470 psi, discharge 800 psi.



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Defense-oriented industries lead in R&D

THE CONTINUING BOOM in research and development characterized by the flurry of activity within the chemical industry obscures a fact which can be disturbing. Specifically, the "Chemical and Allied Products" industry is only an "average" participant as compared to other manufacturing industries.

At times, "average," "mean," and "norm," have no special connotation, but to an industry which prides itself on being a leader the words imply a lag. During an era which has been called the Chemical Century they literally grate on the ears. With billions of dollars yearly of their money being poured into R&D projects, CPI companies can rightfully inquire as to "how come?"

The yardstick

Total funds earmarked for all research and development in the U.S. this year come to over $12 billion according to the National Science Foundation. This is up from $5 billion-plus six years ago. The data is not broken down by industries, however, but by areas, such as federal government, colleges, institutions, and industry as a whole. You have to go to some slightly dated NSF figures to pinpoint how the individual industries fare in the overall picture.

Statistics were obtained by NSF on scientists and engineers engaged in R&D activities within individual industries three years ago and are tabulated in the foundation's annual report for 1959. No breakdown was made on expenditures. However, it's reasonable to assume that R&D outlays are fairly well related to manpower engaged in the respective programs. The figures show that on the basis of percentage of scientists and engineers engaged in R&D activities, Chemicals and Allied Products ranked fourth. Out of 79.2 thousand of these people employed by the industry, 24.3% were assigned to R&D projects.

In the other classifications, aircraft and parts ranked first with 56.7% of its 84.9 thousand scientists and engineers employed in R&D; Electrical Equipment was second with 38.3% of 92.9 thousand in R&D and Machinery was third with 27% of 74.1 thousand engaged in R&D activities. Petroleum Products and Extraction had 7.5% of its scientists and engineers in R&D.

Other manufacturing industries as a whole employed 98.2 thousand scientists and engineers and 24.2% were in research and development. This percentage is almost identical with that of the Chemical and Allied Products group. This is the average participation initially noted. The CPI effort is relatively much lower when scientists and engineers are taken as a whole, for out of 738,000 employed then about one-third were in R&D.

Rationalization

It's difficult to properly interpret the figures without seeing a lot more information than is available. At face value the figures say that the chemical industry is lagging in the overall research effort, and this is not overly pleasant. Rationalizing a bit, it can be said that the two leading industries are deeply enmeshed in governmental defense work requiring heavy emphasis on missiles and electronics. Digging a bit deeper into the figures tends to substantiate this view since the federal government accounts for over half the funds expended in R&D work. While this explains, in part, the chemical industry's lag, in itself it is regarded as a not overly pleasant trend.

Actually, federal agencies accounted for over half the funds spent in the year 1953-1954 when $5.15 billion was spent, and $2.74 billion came from the government and $2.24 billion from industry. The remaining $170 million came from colleges, universities and non-profit institutions. In the 1957-1958 period, outlays had almost doubled to $10.05 billion. While industry increased by 63% to $3.66 billion, the government had a 124% increase to $6.13 billion.

Most of the federal funds do find their way back to industry which contracts to do much of the R&D work. Thus, out of the $10.05 billion spent in 1957-1958, federal government agencies consumed $1.45 billion in R&D projects, while industry accounted for $7.73 billion. Schools and institutions accounted for $870 million. Of the estimated outlays for 1959-1960 for $12.43 billion, governmental agencies will use up $1.78 billion and industry $9.4 billion.

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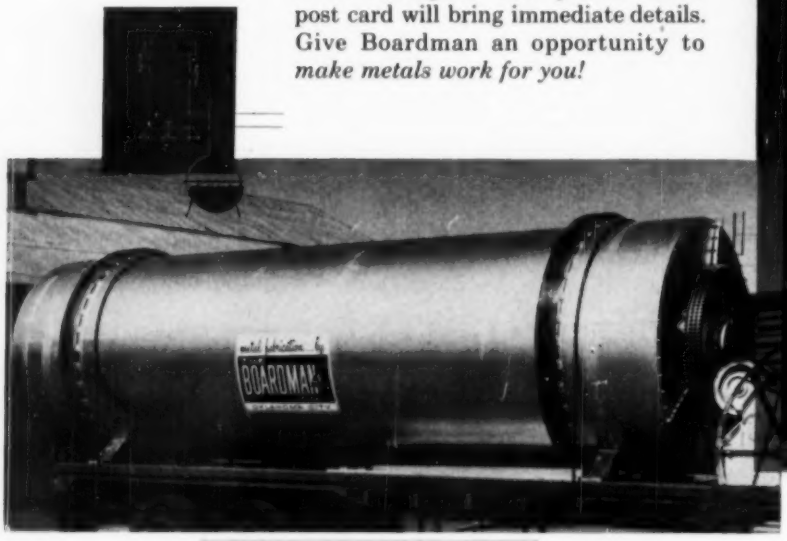

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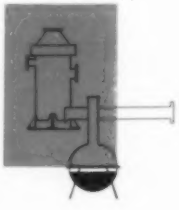

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opinion and comment

Nuclear power?

IT IS FIFTEEN YEARS since the first optimistic estimates that "economical nuclear power is only ten years away," but uncertainty still surrounds the atom as a competitive power source. Had all the experts been right in 1945, the primary questions that now puzzle the nuclear field would have been answered five years ago. However, the father we get from the rosy optimism of the forties, the more doleful the predictions become. Now, as then, for all practical purposes, the only customer the nuclear field has in the United States is the Government.

The private concerns in the field are counting on the future, and estimates as to when power will be economical vary from ten years from now to 2060 A.D. Had nuclear engineering been a normal scientific and engineering development, we would know what the prospects are. The secrecy that has surrounded the atom, however, led to economic uncertainties: what could design be based on?—how much would the Government pay for plutonium?—how much would uranium cost?—how much safety had to be built into a reactor?—what about insurance rates?—what "security" rate per kilowatt?

Two excellent Government publications available last month, both published by AEC, review nuclear prospects: one a summary of the Civilian Power Program; the other the Annual Report of the AEC to the Congress. These are partially reviewed in Scope, page 15 this month, and the status of the program in the U. S. is perhaps best revealed by the following quote:

"Under very optimistic assumptions, it is possible to project development and construction programs which might be expected to bring the cost of power from certain reactor types—light and heavy water reactors, organic-cooled reactors, sodium-cooled reactors including fast reactors and those moderated with graphite—down to a range of 7 to 8.5 mills per kilowatt hour. At these costs, the reactor systems could become competitive with conventional plants using fuel costing from 35 to 40 cents per million B.t.u., which constitute some 20 to 25 percent of existing installed capacity of United States utility systems."

Perhaps we are at a crucial moment in nuclear history. Those engineers who know the field, who are hardheaded about it, think that the atom could be economical right now. On a B.t.u. basis, they say, nuclear power could cost half what power costs from fossil fuels. The key, in the opinion of these engineers, is standardization.

If we could count on reduced costs for security, if we could raise power output of all plants built and building by 2 (the Shippingport plant output was increased by this factor), if one type of reactor and one type of fuel element could be standardized, nuclear power would be feasible in the United States.

These are big ifs, but our present position seems to be that engineering thinking must begin to prevail if the nuclear field is ever to be independent of Government subsidy. To put it more bluntly, we must freeze one process so that the engineers may begin to design and build. F.J.V.A.

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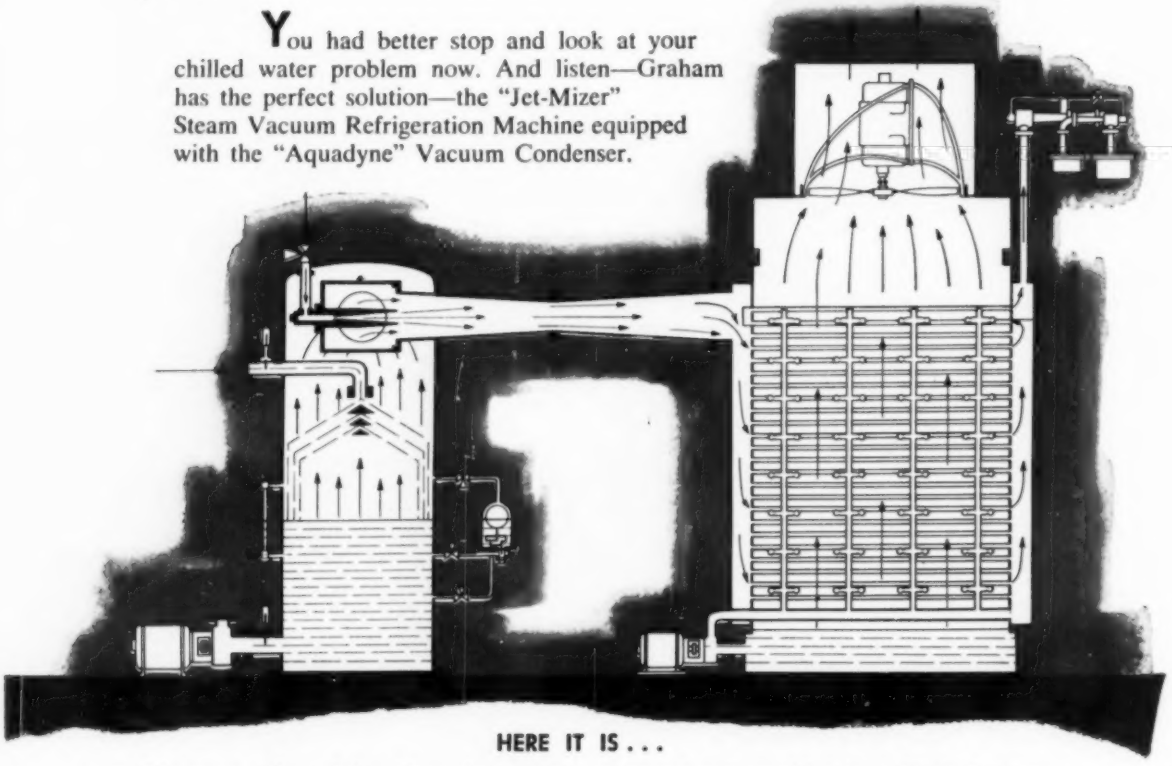

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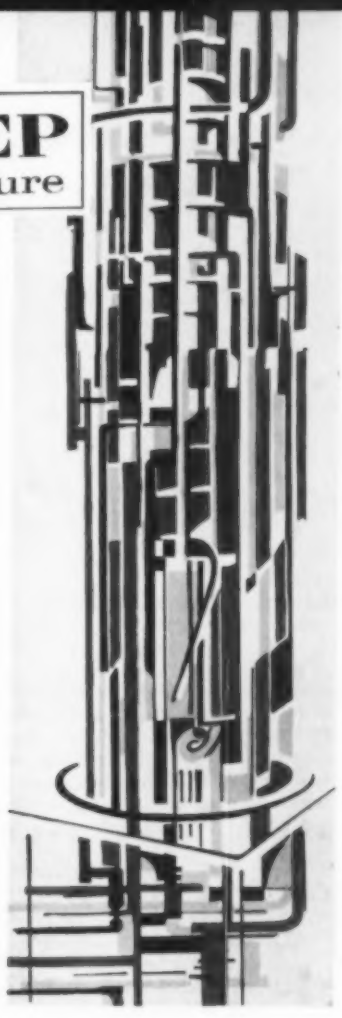

Pilot plant data for hydrogen isotope distillation

Here's the final report containing operating data for the low temperature recovery of deuterium from hydrogen reported in the June 1958 issue of CEP.

In just a little more than twenty-five years since its discovery (*1*), deuterium has risen from the ranks of a laboratory curiosity to that of an essential element. Consider, for example, the application of deuterium oxide, (heavy water) as a nuclear moderator. A typical power reactor requires approximately one ton of heavy water for each megawatt of installed electrical capacity (*2*). Heavy water is already intended for use in 10 or 11 power reactors and some 20 research reactors, and is being considered for use by the Euratom and Great Britain nuclear power authorities. Conservative estimates show a need for about 200 tons of heavy water now with larger potential demand in the future (*3*).

Because of the low natural abundance of deuterium in hydrogen (130 to 150 ppm), enormous quantities of hydrogen would need to be processed. Over 500 billion std. cu. ft. of hydrogen would be required to yield the 200 tons of heavy water mentioned above. If the hydrogen is produced solely as a deuterium source, the cost becomes prohibitively high, around $75/lb. of heavy water (*4*).

To reduce this figure, heavy water plants generally are designed as parasites to plants producing hydrogen for other uses, *e.g.* ammonia synthesis (*5*). This arrangement substantially reduces the cost of the heavy water, but naturally limits the capacity of the parasite to a fraction of that of the host plant. For example, if ammonia plants were the source of the hydrogen, then a combined ammonia capacity of 870,000 tons, about one-third of the present total U. S. production, is required to produce 200 tons of heavy water*.

The use of ammonia plants as a source of hydrogen has disadvantages. While their combined capacity is apparently a sufficient source of hydrogen, it is not likely that the capacity of each plant would meet the most economic requirements of a heavy water plant, nor that the location of each ammonia plant would necessarily be the best for a heavy water plant. In addition, from the deuterium producer's viewpoint, hydrogen from ammonia plants contains large amounts of impurities which are expensive to remove.

Therefore, although ammonia and similar hydrogen producing plants represent one source of deuterium, each case has to be considered on its own merits. Parasitic deuterium plants have advantages, but other possibilities also merit attention.

Water as a deuterium source

All naturally occurring hydrogen compounds have approximately the same deuterium to hydrogen ratio as does hydrogen itself (*6, 7, 8*). Since water is the most abundant source of hydrogen, it immediately attracts our attention as a source of deuterium, and is, of course, already used for this purpose in water distillation, exchange, and electrolysis plants (*9*).

All of these plants characteristically process water, producing heavy water,

* *Based on a natural deuterium abundance of 136 ppm, 90% conversion of hydrogen to ammonia, and on 86% recovery of deuterium from hydrogen.*

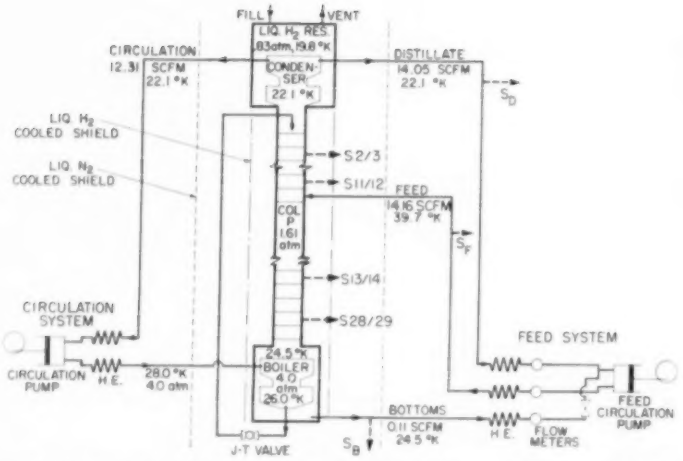

Figure 1. Schematic of pilot plant column with data for a typical partial reflux run.

and have the associated disadvantages of large bulk, high heat requirements, and large capital investment. Let us consider a scheme which may avoid some of these difficulties. It is one which is parasitic to a water source, but which processes hydrogen to yield deuterium.

Such a scheme is represented by the block diagram of Figure 2. The plant has three principal components:

(1) A source of normal water such as a river or lake,

(2) A device for transferring deuterium from water to a hydrogen stream, and

(3) A device for extracting deuterium from the hydrogen stream.

Let us call device (2) a hydrogen-water exchange reactor and device (3) a hydrogen-deuterium stripper, (*e.g.*, a hydrogen distillation plant).

Exchange reactors are already in wide use (*10*), but the one discussed here differs from those in two important respects. First, it is intended to enrich the hydrogen stream rather than the water; and second, the degree of enrichment is only to or near the natural abundance.

Chemical exchange process

Separation by chemical exchange makes use of the reaction

$$H_2O + HD = HDO + H_2 \quad (1)$$

in which the ratio of deuterium to hydrogen at equilibrium in one pair of isotopic compounds (H_2O, HDO) differs from the ratio in the other pair (H_2, HD). When these two pairs of compounds are moved countercurrent to each other in different phases, separation of deuterium from hydrogen may be accomplished in a manner similar to the separation of different chemical species by gas-liquid adsorption or liquid-liquid extraction.

The hydrogen-deuterium exchange can be one of two types: (1) a simple chemical exchanger, for chemical conversion of one deuterium rich compound to the other, or (2) a "dual temperature" exchanger in which a second exchanger appears at a different temperature from the first, with a different equilibrium constant.

The simple exchange process would employ a steam-hydrogen exchange. Hydrogen which has been stripped of deuterium in the distillation plant is mixed with an excess of steam, heated to an elevated temperature and passed through a reactor where the exchange reaction

$$HDO + H_2 = HD + H_2O \quad (2)$$

takes place, thus increasing the HD content of the hydrogen. The gases are then cooled, the steam condensed and separated as water and the hydrogen enriched in HD is recycled through the distillation plant.

The hydrogen-steam exchange reaction has been studied by Cerrai, *et al.*, (*11*) and the equilibrium constants found as a function of temperature are shown in Figure 3. They also pointed out that reaction temperatures above 600°C might be impractical for catalysis by materials of construction might become so rapid that the reaction would revert to the 600°C equilibrium as the gases cooled down.

The mol fraction HD in the hydrogen stream fed to the distillation plant can be easily related to the other streams of the plant. Let the equilibrium constant

$$K = \frac{(HD)\ (H_2O)}{(H_2)\ (HDO)} \quad (3)$$

and

S = $(H_2O)/(H_2)$, the steam to recycle hydrogen ratio,

R = fraction of deuterium stripped by the distillation plant,

C_o = $(HDO)/(H_2O)$, the natural abundance of deuterium in water,

C = $(HD)/(H_2)$, the concentration of HD in the hydrogen fed to the distillation column.

Then by an overall material balance on the total number of mols of deuterium in both its forms, HDO and HD, an expression for the distillation feed concentration is given by the following equation:

$$C = \frac{C_o K S}{(S + KR)} \quad (4)$$

This equation shows that the deuterium to hydrogen ratio increases with increasing steam to hydrogen ratio S, and with increasing K (higher temperatures). Figure 4 shows the

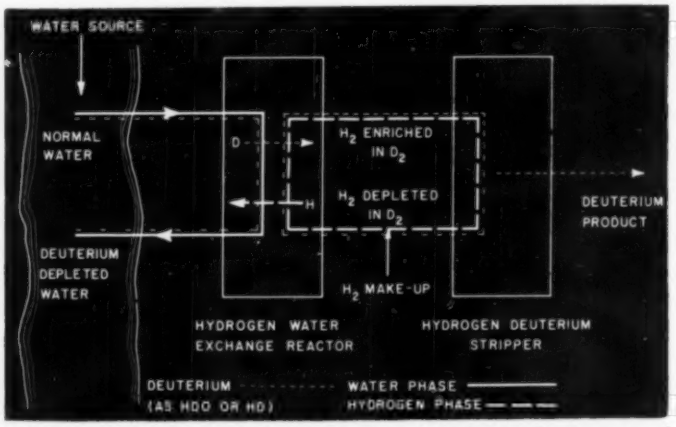

Figure 2. Block diagram for the stripping of deuterium from a normal water source.

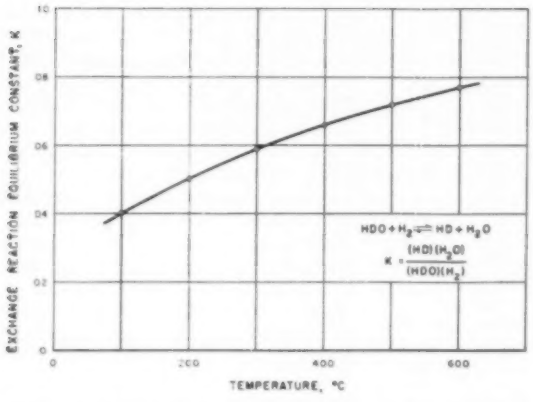

Figure 3. The effects of temperature on the exchange reaction equilibrium constant.

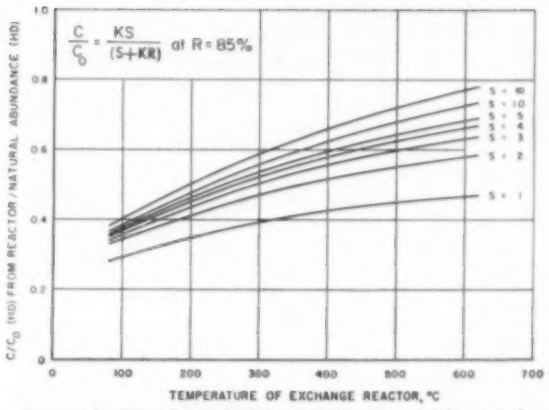

Figure 4. Plot of the parameters for the enrichment due to the exchange reaction.

ratio C/C_o as a function of S and T. The ratio C/C_o was chosen as the ordinate, for it represents the approach of this process to one having a natural hydrogen feed ($C/C_o = 1.0$).

The exact choice of process variables is, of course, an economic one. However, a few broad conclusions can be drawn from Figure 4. The feed stream to the distillation plant will contain only about 70% of the deuterium that would be available from a natural hydrogen source (*e.g.*, from an ammonia plant). Therefore, for a given deuterium production, the distillation plant would be larger than one associated with an ammonia plant. However, the distillation plant would be simpler, because the use of recycle hydrogen eliminates the need of separating large amounts of nitrogen or other impurities. The principal advantages of this system are that it is not parasitic, and that it is comparatively simple.

Dual-temperature exchange process

The other type of hydrogen-water exchange is the dual-temperature process. Fitted into the hydrogen distillation heavy water plant, this process would be used to enrich water, which in turn enriches the recycle hydrogen by steam hydrogen exchange. Figure 5 is a simple flow diagram showing the principle of this process.

The exchange reaction in the cold reactor may be considered as the reverse of the steam-hydrogen exchange. The equilibrium constant for this reaction is about 2.8 for low temperatures, K_1, and 1.3 for high temperatures, K_2. Therefore, deuterium will be transferred from hydrogen to steam in the cold reactor, and from steam to hydrogen in the hot. In this process, the circulating hydrogen may be considered simply as a carrier, which strips water of deuterium at high temperatures, and enriches water at lower temperatures.

An analysis similar to the one for the simple steam-hydrogen exchange leads to the following equations:

$$(C_w/C_o) = 1 - S^2\left[\frac{K_1 - K_2}{K_1 + K_2 + K_1K_2S}\right] \quad (5)$$

$$(C_F/C_o) = 1 + S^2\left[\frac{K_1 - K_2}{K_1 + K_2 + K_1K_2S}\right] \quad (6)$$

Where C_w and C_F represent the concentration (HDO) / (H_2O) of the depleted water and the enriched water respectively (Figure 5).

For the particular case of Figure 5, and with a steam-hydrogen ratio of one ($S = 1$), the steam from the cold reactor is enriched to 1.19 times the natural abundance, and the steam from the hot reactor is depleted to 0.81 times the natural abundance. The enriched steam then feeds a simple steam-hydrogen exchanger. Equation 4 indicates that the hydrogen from such a reactor will gain about 70 percent of the deuterium from the steam fed to it. Therefore, the hydrogen from this exchanger contains (0.70) (1.19) = 0.883 times the natural abundance of deuterium.

More sophisticated dual temperature exchange plants have been designed. One by Cerrai *et al.* (*11*), which is still fairly simple, yields a water product enriched to 1.464 C_o. This in turn would supply hydrogen for distillation with 1.025 times the natural deuterium content.

Schemes of this sort make the hydrogen distillation plant independent of a large source of hydrogen, so that any suitable body of water can be regarded as a source of deuterium. Another real advantage is that the hydrogen to be distilled requires no extensive purification. Although these two gains are partially offset by an increase in the overall size of the plant, processes of this type are interesting enough to warrant further study.

Hydrogen distillation plant

Regardless of the source of hydrogen, the heart of the hydrogen-to-heavy-water plant is the distillation process. Hydrogen distillation has been the subject of many theoretical papers (*12, 13, 14, 15, 16, 17*) but this interest has resulted in little actual equipment because of the lack of design data and limited experience with liquid hydrogen.

The latter difficulty is being overcome as larger and larger amounts of liquid hydrogen are produced for the defense effort (*18*). To provide experience with equipment, a three year research program was conducted at the National Bureau of Standards Cryogenic Engineering Laboratory, Boulder, Colorado, to experimentally evaluate the design parameters for hydrogen distillation.

The results of preliminary studies covering such items as plate design and geometry, weir height, downcomer area, plate spacing, etc., have already been published (*19*). These studies culminated in the design and operation of a hydrogen distillation pilot plant. The design of this plant was covered in the same article (*19*), but details of its operation have not previously been reported.

The pilot plant column, which is six inches in diameter and contains thirty actual plates, has been operated repeatedly during the past year for periods of three to five days with no serious difficulty. One run proc-

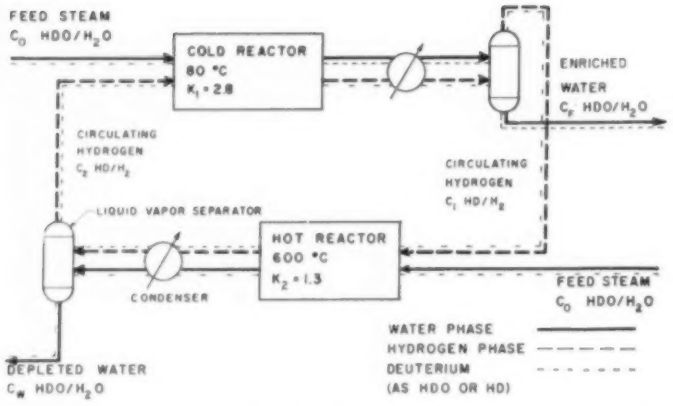

Figure 5. Flow diagram of a dual-temperature exchange process for enriching water.

essed 3400 std. cu. ft. of hydrogen and yielded a by-product depleted of its deuterium content by a factor of thirty. The column was operated with vapor velocities ranging from 0.2 to 2.0 in./sec., and reflux ratios from total to an (L/D) of 2.05. A flow diagram of the pilot plant column showing typical operating data is shown in Figure 1 and recorded in Table 1.

The principal object of experimental runs was to determine the over-all plate efficiency. Taps, located at seven points along the column, fed gas phase samples to a continuously recording thermal-conductivity analyzer (*20*). These analyses were recorded along with the other process variables so that the over-all plate efficiency could be determined as a function of vapor velocity.

Since deuterium occurs naturally in the form of HD rather than D_2, the pilot plant was designed to separate the system H_2 — HD. The column was designed to increase the concentration of HD in H_2 from its natural abundance of 0.03% to 3%, and to have a capacity equivalent to the production of 45 lbs. of heavy water in an 8000 hour year. However, all the experimental work reported here was carried out with the H_2 — D_2 system, for D_2 is readily available and HD is not. The use of the H_2 — D_2 system in the experimental work rather than the H_2 — HD system is readily justified. Since the two pairs have very similar physical properties, they can be expected to behave similarly on a plate. As an index for comparison, the Drickamer and Bradford (*21*) correlation predicts the two systems will have the same over-all plate efficiency. The O'Connell (*22*) correlation predicts a plate efficiency for the HD system only slightly higher than that for the D_2 system.

Before any method of analysis can be applied to determine the number of theoretical plates in the column, the relative volatility of the system must be known exactly. Newman (*23*) has done some excellent work on the activity coefficients of the hydrogen-deuterium system. To facilitate the calculations, his data were fitted by the method of least squares to give equations for the activity coefficient (γ) as a function of the volume fraction (ϕ) over the entire concentration range and temperature (T, °K). These equations for the activity coefficients of hydrogen and deuterium, which represent the positive deviation of the system from Raoult's law are shown at bottom of the page where:

$$\phi_H = \frac{N_H V_H}{N_H V_H + N_D V_D}$$

$$\phi_D = \frac{N_D V_D}{N_H V_H + N_D V_D}$$

N = mol fraction
V = molar volume

A special program was then written for the IBM 650 computer. If the data set was that of a partial reflux run, the program computed a complete vapor-liquid equilibrium curve corrected for non-ideality. The McCabe-Thiele analysis was then made by hand to determine the number of theoretical plates. If the data were that of a total reflux run, the program branched to calculate the over-all plate efficiency by the Fenske-Underwood method. In either case the vapor velocity within the column was also one of the parameters calculated. The results of this analysis are shown in Figure 6.

These plate efficiencies represent data for runs during which the reflux ratio was varied from total to a ratio of 2.05, and during which the composition of the mixtures on the plates varied from pure hydrogen to 98% deuterium in hydrogen. No dependence of over-all efficiency on either reflux ratio or composition could be found.

Three points at low vapor velocity, from 0.1 to 0.5 in./sec., group themselves around a low value of plate efficiency. This behavior at low vapor velocities is not at all uncommon and has been reported by several authors (*24, 25*) who investigated higher boiling systems. The effect is one of

Table 1. Data of typical run.

Flow rates		
Stream	Std. cu.ft./min.	g mols/min.
Bottoms	0.11	0.14
Feed	14.16	17.89
Distillate	14.05	17.75
Circulation	12.31	15.55

Pressure	
Point	Pressure (abs.)
Circulation (interior of reboiler)	4.0 atm
Column (exterior of reboiler)	1.61 atm
Hydrogen reservoir	0.83 atm

Temperature	
Point	Deg. Kelvin
Bottoms (exterior of reboiler)	24.5
Feed (into the column)	39.7
Distillate (top of column)	22.1
Circulation (into reboiler)	28.0
(interior of reboiler)	26.0
Hydrogen reservoir	19.8

Analyses	
Sample	Composition mol % D_2
Bottoms	96.9
Feed	0.77
Distillate	0.015
Circulation	0.015
28/29	87.0
13/14	1.0+
11/12	1.0—
2/3	0.035

$$\text{Log}_{10}\gamma_D = (\phi^2_H)[0.626426 - 0.486436\,(\frac{T}{10}) + 0.0989286\,(\frac{T}{10})^2] \quad (7)$$

$$\text{Log}_{10}\gamma_H = (\phi^3_D)[0.257532 - 0.129184\,(\frac{T}{10}) + 0.015184\,(\frac{T}{10})^2] \quad (8)$$

hydraulics on the plate and not one due to peculiarities of a given system. It is therefore reasonable to expect to find this behavior even in the liquid hydrogen system at sufficiently low vapor velocities. The effect is generally ascribed to a coning or jetting of vapor through the liquid on the plate. At very low vapor velocities the vapor does not distribute itself evenly over the plate, but tends to jet up through small areas of the plate. Irregularities on the plate surface, such as an unevenness in the mesh size, provide centers from which the jets form. This non-uniform mixing of the liquid and vapor naturally tends to produce lower plate efficiencies than would thorough mixing. Since this effect does exist, one should be cautious not to extrapolate the low velocity segment of plate efficiency curves.

All of the earlier work on small columns (*19*) can be shown to fit curves of the form

$$\ln E_o = \lambda U + b \qquad (9)$$

where

E_o = overall plate efficiency
U = superficial vapor velocity, in. per sec. and
λ, b = parameters.

This idea may reasonably be extended to give an extrapolating function for the plate efficiencies of the pilot plant:

$$\ln E_o = -0.100\ U + 4.122 \qquad (10)$$

This function was used to calculate the extrapolated values (dotted line) in Figure 6.

Whenever plate efficiencies were computed using sample data taken from the reboiler, a noticeable increase in efficiency was indicated. A reasonable explanation for this considers the wetted wall effect of the 1½ in. dia. downcomer that extends below the bottom plate into the reboiler. The equivalent wetted length

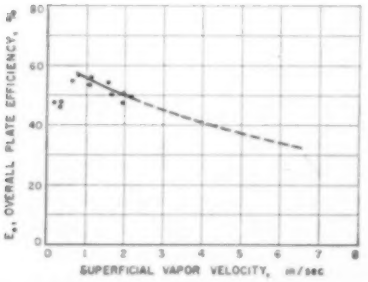

Figure 6. Plate efficiencies for a column having plates made of 40 mesh screen spaced 4 in. apart with ¾ in. weir and 10% downcomers.

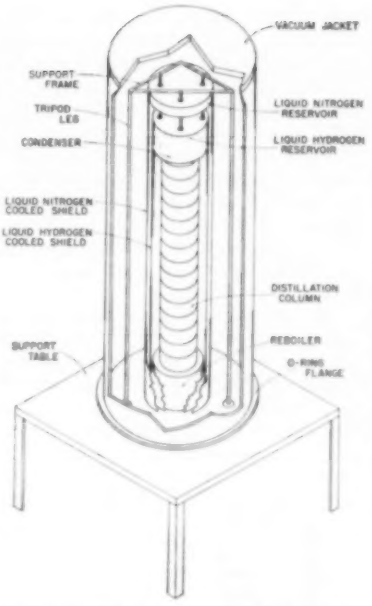

Figure 7. Details of insulation of pilot plant column.

of this downcomer is 1⅛ in. Earlier data (*19*) indicated an HETP of six in. for a wetted tube of this diameter; consequently, this downcomer could contribute 0.25 theoretical plates to the separation. The number of theoretical plates that existed between the reboiler and the lowest sample tap in the column varied between one and two. Hence, the wetted wall effect of this downcomer was a significant fraction of the total separation effect present. In order to compute an overall efficiency free from this wetted wall effect it was necessary to subtract the 0.25 theoretical plates due to the downcomer from the number of theoretical plates corresponding to the observed separation. Plate efficiencies computed in this manner agreed very well with those computed for regions of the column in which no wetted wall effect existed.

Heat transfer problems

One dubious point in the design of the pilot plant was the proper choice of heat transfer coefficients for the design of the reboiler and condenser. The data of Figure 7 (*19*) were used in the design, and proved to be accurate. A recent publication by Malkov (*26*) indicates that these values may be low. However, our experience was to the contrary and it is suggested that overall heat transfer coefficients, from 20 to 30 Btu./(hr.)-(sq. ft.)-(°F) and temperature differences of 2 to 4°F are safe design values.

In systems boiling above ambient temperature heat leak is away from the column and has the effect of increasing the reflux ratio and the reboiler duty. In low temperature systems the effect is just the opposite. Heat leak is to the column, thus decreasing the reflux ratio and increasing the refrigeration load.

The gas formed by liquid evaporated from the hydrogen and nitrogen reservoirs was metered under known temperature and pressure conditions and gave a measure of the heat leak to the hydrogen and nitrogen systems. It was necessary to avoid making such measurements during transfer of liquid to the reservoir because any such measurement would also include the heat leak to the transfer line. When such measurements were made during the distillation run it was also necessary to have accurate values for energy input to the reboiler, since the hydrogen evaporation rate during distillation would naturally include this value.

The heat leak values obtained in this manner should not be compared with those estimated from radiation effects only. Heat leak to the nitrogen system, for example, includes not only that due to radiation, but also that due to conduction through the residual gas present in the vacuum space, conduction through the tripod legs, and through the transfer and vent lines attached to the nitrogen reservoir. Similarly, heat leak to the hydrogen system includes not only the radiation, but also residual gas conduction and conduction through the hanger rods and through the many lines that enter and leave the column and hydrogen reservoir. The values presented do, however, serve as a practical guide to the refrigeration required by such a column.

The values of heat leak measured for the apparatus with a vacuum of 10^{-6} to 10^{-7} mm Hg in the vacuum

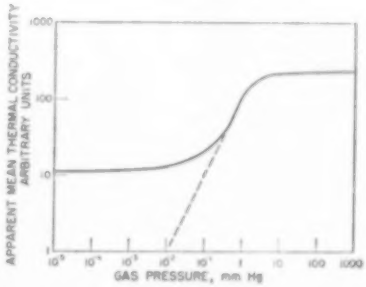

Figure 8. Variation of the apparent thermal conductivity of a typical insulating powder as the interstitial gas pressure is changed.

space and with both systems cooled to their respective liquid temperatures are:

1) To the nitrogen system: 140 watts
2) To the hydrogen system: 31 watts

Insulation

As has already been reported (*19*), the column was insulated by two concentric radiation shields at 76°K and 20°K, all enclosed in a high vacuum space (Figure 7). This method of insulation was chosen because it allowed ready access to the column. However, on an industrial scale where frequent inspections and changes are not anticipated, the use of powder insulation or the recently developed "Super Insulations" may be more desirable.

Figure 8 gives some of the typical properties of powder insulations. At ambient pressures the apparent thermal conductivity is approximately that of the gas. This implies that the heat transferred by solid conduction through the powder is relatively small and also that the powder inhibits to some degree heat transfer by convection and radiation.

As the interstitial gas pressure is reduced by pumping, the rate of heat transfer is at first little affected because the thermal conductivity of the gas is nearly independent of pressure in the higher pressure region. As the gas pressure is further reduced, the mean free paths of the molecules become comparable with interstitial distances and there is a marked reduction in apparent thermal conductivity.

If the only mechanism for heat transfer were gaseous conduction, the rate of heat transfer at all lower pressures would be proportional to the gas pressure (dotted line, Figure 8). However, it is found that at these lower pressures the rate of heat transfer is almost independent of the pressure, indicating that heat is being transferred by other means. This may be by solid conduction through the powder, by radiation, or by both.

Two broad conclusions can be drawn from Figure 8. If the powder is pumped, pressures less than one micron give no advantage. That is, the high vacuums usually associated with cryogenic insulation are not required. Secondly, if the powder is not evacuated, at least heat transfer by radiation and solid conduction are eliminated.

Some difficulties arise with the use of powders since the insulation near the 20°K surface will also have a low temperature, thus liquefaction of residual air or air in the cells of the powder might seriously reduce the insulation efficiency. To avoid this, a two-layer-insulation can be applied. The internal layer, having an operating temperature below the air dewpoint is enclosed in a vacuum tight casing, and the enclosed material is filled with hydrogen or helium. The location of this internal jacket can be readily determined from the heat conductivity of the insulation layer both filled and not filled with hydrogen. Or, the system can be made simpler by filling the entire insulation with hydrogen or helium.

The overall size of the unit can be reduced by optimally placing a liquid nitrogen cooled shield within the insulation. On larger installations, where the thickness of the insulation does not materially affect the size of the unit, such a shield would probably be omitted. However, use of shields is almost obligatory for smaller units.

T. M. Flynn's special field of interest is cryogenics — the physical equilibria of cryogenic systems and processes. Flynn did his undergraduate work at Rice Institute. He has an MS and PhD from the University of Colorado where he also taught for three years as a member of the chemical engineering faculty. Flynn has worked with Magnolia Petroleum in Texas, and with Shell Oil's Houston refinery. He is now with the Cryogenic Engineering Laboratory, National Bureau of Standards, Boulder, Colorado.

The recently developed "Super Insulations" have a mean effective thermal conductivity one-tenth that of the best evacuated powder insulations (*27*). These thermal insulators consist of alternating layers of good reflectors separated by poor conductors, such as aluminum foil and glass. They have found wide application in transportable dewars due to their small weight and size, and may prove useful in insulating stationary equipment. However, in cases where the thick insulations are tolerable, powders may still be used since they are easier to install than the multiple layer insulations.

Summary

Recent careful work on the ideality of mixtures of H_2 and HD has made it possible to accurately evaluate the vapor-liquid equilibria of the H_2 – HD system. With this information it is possible to show that the separation by fractional distillation is not a difficult one and that the number of equilibrium stages required is not large.

Previous experimental work on plate efficiency and other design parameters such as allowable vapor velocity, plate spacing, weir height, and downcomer area permitted the design and operation of a pilot plant. The pilot plant is capable of increasing the concentration of HD in H_2 from its natural abundance, 0.03%, to 3%, and has a capacity equivalent to the production of 48 pounds of heavy water in an 8000 hour year.

The column was operated with vapor velocities ranging from 0.2 to 2.0 in./sec. and reflux ratios from total to a finite ratio of 2.05. Overall plate efficiencies in this range of vapor velocities were found to vary from 45 to 55%.

This data, coupled with the growing experience in handling liquid hydrogen can be used in the design and operation of reliable and efficient hydrogen distillation plants. These plants can be made either parasitic to or independent of large hydrogen sources. These plants will combine the merits of short equilibrium time, relatively low capital investment, and low unit cost of heavy water.

LITERATURE CITED

1. Urey, H. C., F. G. Brickwedde, and G. M. Murphy, *Phys. Rev. 39*, 164 (1932).
2. *Anon., Chem. Week 81*, 14, 31 (1957).
3. *Ibid.*, 33.
4. Benedict, M. "Survey of Heavy Water Production Methods," *Proc. Int. Conf. on the Peaceful Uses of Atomic Energy, 8*, 339 (1956).
5. *Anon., Chem. Eng. Prog. 54*, 9, 130 (1958).
6. Bradley, C. A., and H. C. Urey, *Phys. Rev., 40*, 889 (1932).
7. Washburn, E. W., and E. R. Smith *J. Research Nat. Bur. Standards, 12*, 305 (1934).
8. Demidenko, S. G., *Acta Physicochem U. S. S. R., 13*, 305 (1940).
9. Murphy, G. M., H. C. Urey, and I. Kirshenbaum, "Production of Heavy Water," McGraw-Hill Book Co., Inc., New York (1955).
10. Anon., *Chem. Week 81*, 14, 33 (1957).
11. Cerrai, E., C. Marchetti, R. Renzoni, L. Roseo, M. Silvestri, and S. Villani, *Chem. Eng. Prog. 50*, 11, 271, (1954).
12. Clusius, K., and K. Starke, *Z. Natur., 49*, 549 (1945).
13. Hydrocarbon Research Co., Inc. "Final Report to U. S. AEC, Low Temp. Heavy Water Plant," Cont. No. AT (30-1)-810. (1951).
14. Selak, P. J., and J. Finke, *Chem. Eng. Prog., 50*, 217 (1954).
15. Akar, P., and G. Simonet, *Proc. 2nd. U. N. Conf. on Peaceful Uses of Atomic Energy, 4*, 522 (1958).
16. Gami, D. C., *et al., loc. cit. 4*, 534 (1958).
17. Bailey, B. M., *loc. cit. 4*, 556 (1958).
18. *Anon., Chem. and Eng. News, 37*, No. 20, 32 (1959).
19. Timmerhaus, K. D., D. H. Weitzel, and T. M. Flynn, *Chem. Eng. Prog. 54*, No. 6, 35 (1958).
20. Purcell, J. R., J. W. Draper, and D. H. Weitzel, *Proc. 1957 Cryogenic Eng. Conf.*, K. D. Timmerhaus, ed., Ch. E. Dept. Univ. of Colo., Boulder, Colo.
21. Drickamer, H. G., and J. R. Bradford, *Trans. A. I. Ch. E. 39*, 319 (1943).
22. O'Connell, H. E., *Trans. A. I. Ch. E. 42*, 741 (1946).
23. Newman, R. B., "Binary Mixtures of H_2, HD, and D_2." Ph. D. Thesis, Univ. of Bristol, Eng. (1954).
24. Peavy, C. C., and E. M. Baker, *Ind. Eng. Chem., 29*, 1056 (1937).
25. Perry, J. H., ed., *Chemical Engineers' Handbook*, 3 ed., McGraw-Hill Book Co., Inc., New York (1950).
26. Malkov, M. P., *et al., Proc. 2nd. U. N. Conf. 4*, 491 (1958).
27. Kropschot, R. H., "Cryogenic Insulation." *ASHRAE Journal, 1*, No. 9, 48-54 (1959).

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Fluid bed conversion of UO_3 to UF_4

Now—a tapered fluid bed reactor for reduction and hydrofluorination of uranium trioxide to uranium tetrafluoride.

The processing of cold enriched uranium compounds has traditionally been carried out on a batch basis using 100 to 500 gram aliquots. This system, though costly, provided nuclear safety both on the basis of geometry and administrative control and allowed direct and positive accounting for material in the process. Increases in throughputs as well as an increase in demand for a variety of special enriched materials has made this procedure impractical.

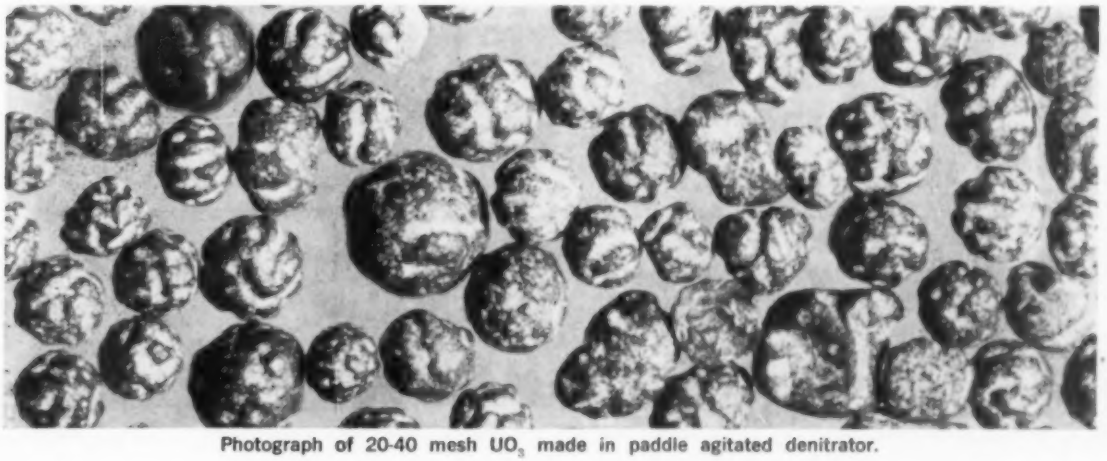
In any new processing scheme, the following criteria must be satisfied: nuclear safety, absolute inventory control, mechanical simplicity, better reagent efficiency, and higher productivity.

A major process involves the production of UF_4 from uranyl nitrate as shown in Figure 1. Cold enriched uranyl nitrate is converted by denitration, reduction, and hydrofluorination to a product stream of 99% UF_4. The identification "cold enriched" indicates the process stream is fission product free and that the uranium content is largely the U-235 isotope. The processing has traditionally been carried out manually in small batches, as this procedure served to maintain inventory control and nuclear safety.

A fluidized bed contactor would be desirable for the reduction-hydrofluorination steps provided the stipulated criteria could be met and a readily fluidizable, sufficiently reactive feed could be produced from uranyl nitrate. Although these reactions have been carried out in fluidized bed reactors by others (*1*), the primary interest was in ore processing or other applications in which the U-235 content was very low. The development of contactors for processing large quantities of enriched material on a semicontinuous basis is described in this article.

Pilot plant equipment

In the new process described, the denitration is performed in an agitated-trough type reactor (*2*). This reactor produces spheroidally shaped UO_3 which is well suited to fluidization. The particle size of the UO_3 produced can be controlled in the range of 20-200 mesh, and it is not subject to attrition during subsequent processing. Typical feed material, as produced, is shown in photograph below.



Photograph of 20-40 mesh UO_3 made in paddle agitated denitrator.

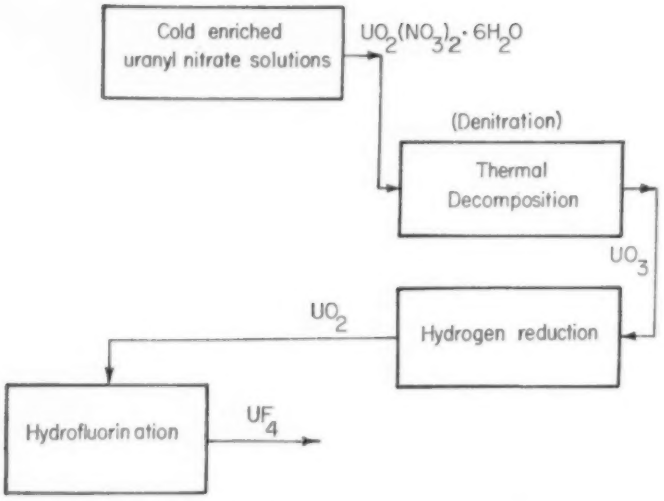


Figure 1. Block flow diagram of a typical uranium processing cycle.

During early efforts, the mechanical feasibility of carrying out the reduction and hydrofluorination steps in a fluidized bed was demonstrated. The pilot reactor is shown schematically in Figure 2. The five inch diameter reactor is the largest consistent with established nuclear safety practice. A block flow diagram of the reactor and controls is shown in Figure 3. The most resistant material of construction was found to be Inconel. The porous metal separators at the top and bottom of the reactor (Figure 2) are of special design but are commercially available (3). These filters completely confine the inventory during reaction.

The over-all reaction cycle includes the pneumatic charging of UO_3, reduction, hydrofluorination, and pneumatic evacuation of product UF_4. The minimum cycle was four to five hours with a forty pound charge. The reduction cycle is one hour at 1020°F. The hydrofluorination is one hour at 400°-600°F followed by one hour at 600°-1300°F.

Rate determining processes

Studies aimed at attaining maximum productivity indicated the primary rate controlling processes are: basic reaction kinetics, reagent delivery, and heat transfer. It was further determined that, under certain conditions, only the reaction kinetics limits productivity.

The kinetics of the reduction reaction was studied thermogravimetrically (4), and it was found that the reaction is approximately first order (solids). The range of interest was found to be 1020°-1060°F and the reaction was found to require 40 and

Table 1. Summary of fluidization velocity data.

Data obtained in 5-in. reactor, 40-lb. charge, bed depth approx. 24 in. (velocities are at bed exit).

Feed Mesh Size Tyler Series	Fluidization *Vel. H_2 at 1000°F, ft./sec.	Fluidization *Vel. N_2 at 500°F, ft./sec.	Fluidization *Vel. HF at 500°F, ft./sec.
20-35	3.5-4.0	3.0-3.5	1.5-2.0
35-60	1.5-2.0	1.3-1.5	0.7-1.0
65-100	0.8-1.0	0.6-0.8	0.5-0.7
-100	0.3-0.4	0.3-0.4	0.3-0.4
-200 (50%-325)	0.1-0.2	0.1-0.2	0.1-0.2

Velocities at bed exit; 14.7 lb./sq.in.abs.

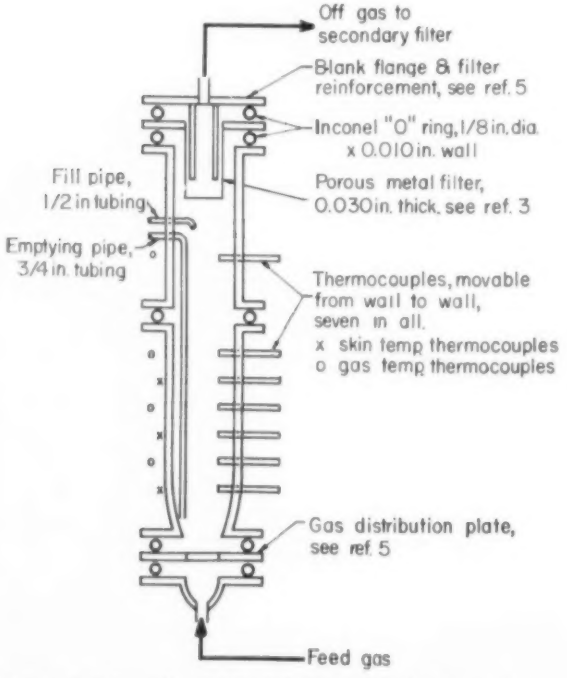

Off gas to secondary filter
Blank flange & filter reinforcement, see ref. 5
Inconel "O" ring, 1/8 in. dia. x 0.010 in. wall
Fill pipe, 1/2 in tubing
Porous metal filter, 0.030 in. thick, see ref. 3
Emptying pipe, 3/4 in. tubing
Thermocouples, movable from wall to wall, seven in all.
x skin temp thermocouples
o gas temp thermocouples
Gas distribution plate, see ref. 5
Feed gas

Figure 2. Schematic of 5-in. fluid bed pilot plant reactor.

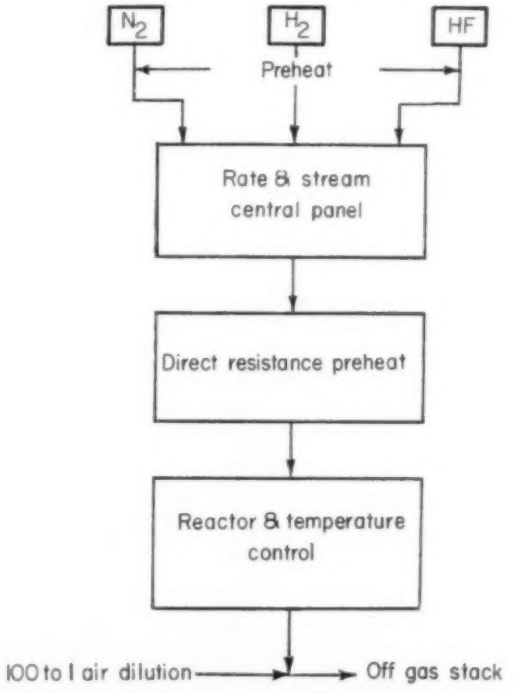


Figure 3. Block flow diagram of a fluid bed pilot plant.

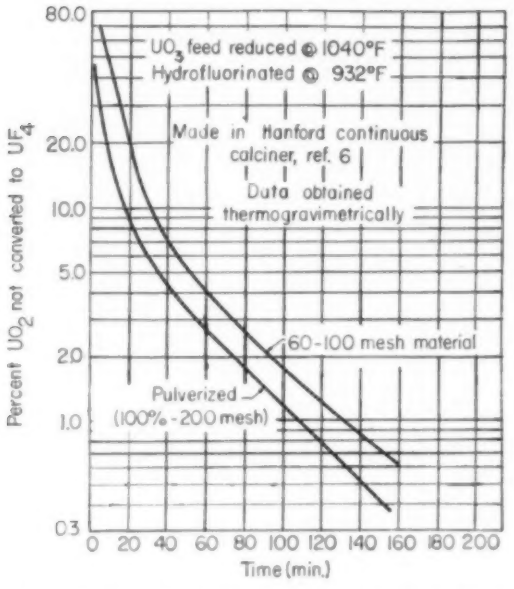


Figure 4. Hydrofluorination data showing effect of reaction time and particle size on the conversion efficiency.

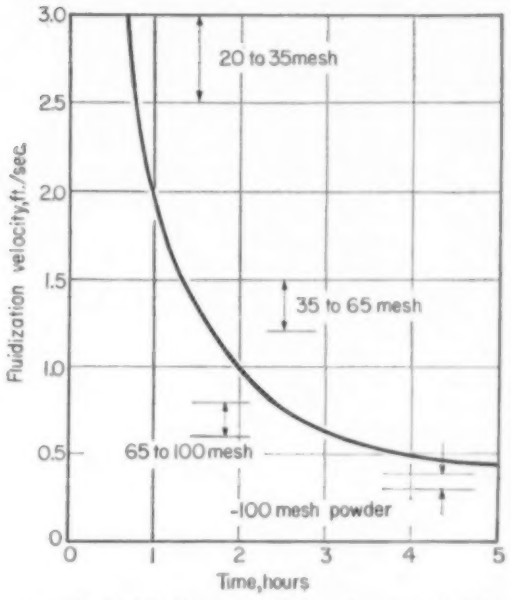


Figure 5. Fluidization velocity vs. time required to pass stoichiometric gas requirement for 60 lb. UO_2 in a 5-in. diameter reactor at 1000° F.

Table 2. Heat transfer coefficients obtained during selected hydrofluorination runs.

No.	Feed Particle Size (Tyler)	Powder to Wall (Btu/hr.-sq.ft.-°F)
20	20-40	49
21	40-60	63
22	20-40	58
36	20-40	65
Selected Runs Based on Heating and Cooling Cycles		
20	20-40	60
21	40-60	51
36	20-40	62

5 minutes, respectively, for 99% reduction at these temperatures. Lower temperatures result in adversely low rates and higher ones make the material unsuitable for hydrofluorination.

The hydrofluorination of UO_2 (produced below 1060°F) was thermogravimetrically studied over the range 400°-1050°F. The reaction was found to approximate a first order reaction at conversions above 90%. Thermogravimetric results indicate 65% conversion can be obtained in one hour at 400°F. At 1000°F, 98% conversion in one hour is attained. The effect of particle size on the reaction rate was slight, as shown in Figure 4.

The conversion rate attainable in a fluidized bed may be limited by reagent addition rate consistent with good fluidization. The pilot plant experience is summarized in Table 1. The data were obtained on the basis of bed pressure drop and bed sound as noted with audio pickups located at various bed elevations. The effect of particle size on reaction time for the hydrofluorination reaction is shown in Figure 5. Were the reagent delivery the rate limiting process, a reactor for 20-35 mesh material would be about one-sixth that of a comparable reactor for 100 mesh material.

Estimates of the heat transfer, bed-to-wall, were made during pilot conversions. The estimates were based on heating and cooling data and on data obtained during selected hydrofluorinations. The bed temperature estimate was based on thermocouple traverses. In all cases the bed temperature was found constant within 2° or 3°F, but no measurements were made closer than one-half inch of the reactor wall. The measured values were found to be independent of particle size in the range of 20-100 mesh. Results are summarized in Table 2.

Tapered column

With the five-in. cylindrical reactor described, the maximum charge was found to be sixty pounds, or a bed depth of about two feet. Operating problems with deeper beds are well known. However, in this application a charge of 100 pounds was desired without exceeding a reactor diameter of five in. Observations of the fluidization of UO_2 in a four-in. glass column are summarized in Figure 6 along with typical pressure drop-velocity data. Boiling was always observed to begin at the upper surface and proceed downward through the bed as the velocity was increased. The bed weight was manifest as pressure drop at about the time boiling

Table 3. A summary of conversion runs made in tapered, fluidized bed batch reactors.

Run No.	UO_2 Charged (lb.)	Mesh Size (Tyler)	Reduction Time (hr.)	Hydrofluorination (hr.)	Reduction (%)	UF_4 (%)
70	20	-200	6	—	90.4	*
71	20	-200	6	8	99.6	97.9
72	20	-200	4	6	97.0	86.8
Special	20	20-40	2	4	99.0	96.0
Special	100	60-325	4	6	99.0	95.0

* *Not hydrofluorinated*

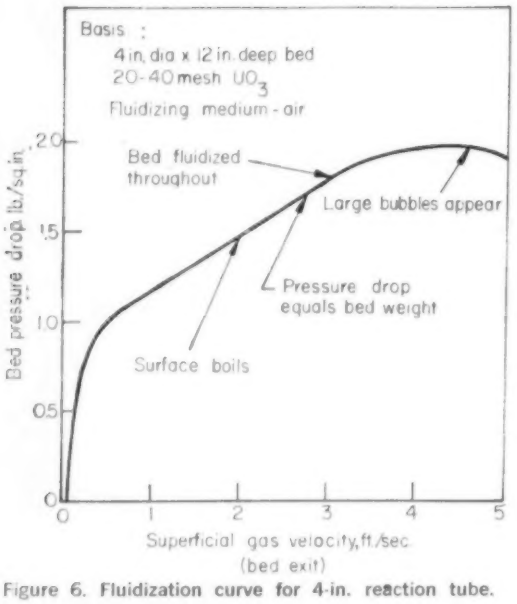

Basis :
4 in. dia x 12 in. deep bed
20-40 mesh UO_3
Fluidizing medium - air
Bed fluidized throughout
Large bubbles appear
Pressure drop equals bed weight
Surface boils
Bed pressure drop lb./sq. in.
Superficial gas velocity, ft./sec (bed exit)

Figure 6. Fluidization curve for 4-in. reaction tube.

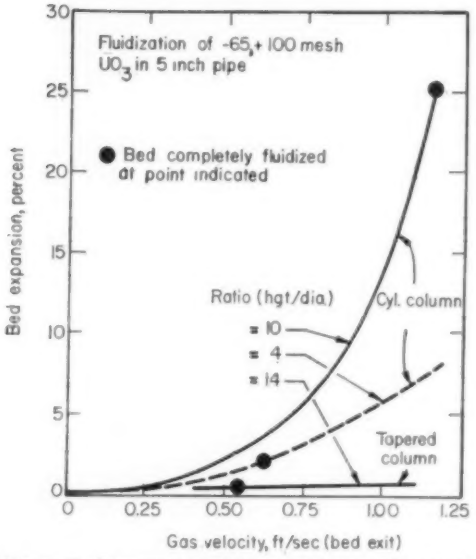


Figure 7. Comparison of bed expansion of tapered and cylindrical columns.

could be seen throughout the bed. The bed pressure drop, it was reasoned, might be accompanied by sufficient velocity increase to cause the nonuniform boiling. This thought was supported by the observation that boiling was more severe in deeper beds. In conformity with this pressure drop-velocity concept, a glass column with a ¼° taper was fabricated. This taper was computed to provide a constant velocity profile for this material. Observations with this column were striking. When operating under conditions identical with cylindrical columns, almost no boiling or expansion was noted—even in very deep beds.

The expansion-velocity relationship for three columns of interest is shown in Figure 7. The dotted line represents the conventional case. The upper curve shows a ten diameter deep cylinder. The expansion is extreme and a much higher velocity than for a shallow bed is required for complete fluidization. The lower curve represents a tapered column of fourteen diameters' depth. The expansion is extremely small, even at a velocity twice that required for fluidization. The solids flow pattern so well known in cylinders is absent in the tapered unit. In tapered columns, it was noted that at velocities substantially above the minimum bubbles do appear, but they do not coalesce and in many cases disappear before reaching the upper surface. Photographs of the upper portion of the tapered and cylindrical columns both at rest and in action are shown in Figures 8 and 9.

A tapered Inconel reactor was fabricated and conversions were per-

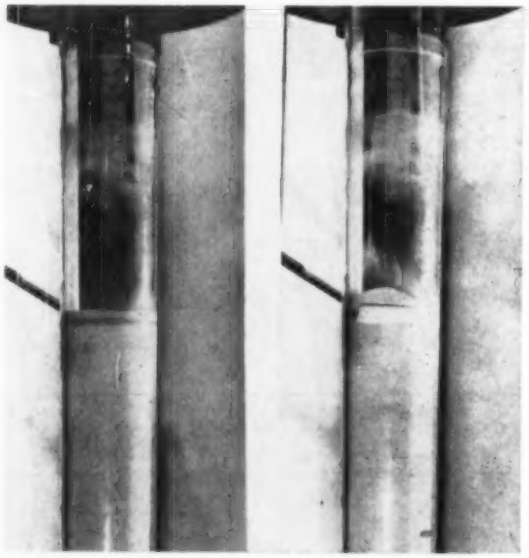


Figure 8. Tapered column with 5-ft. bed of 20-40 mesh UO_3 powder at rest (left) and when fluidized at velocity of 3 ft./sec. (right).

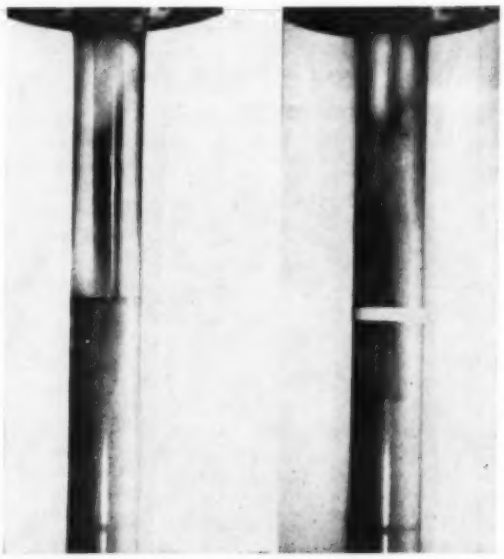


Figure 9. Cylindrical column with 4-ft. bed of 20-40 mesh UO_3 powder at rest (left) and when fluidized at velocity of 3 ft./sec. (right).

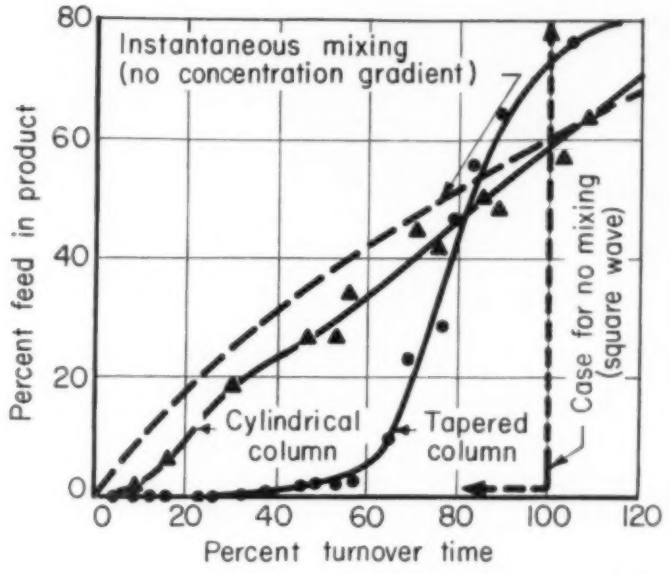


Figure 10. Mixing data of UO_2 into UO_3 in a continuous fluid bed operation for a turnover time of 3.14 hours.

formed with powder from 20-40 to finer than 300 mesh. Charges up to 100 pounds have been readily processed. Typical data are shown in Table 3.

The utility of the tapered column in the batch operation is clear, and satisfactory operation on a production basis has been achieved. However, the qualities of stability at great depth, noncaking characteristics, and lack of mixing proven in this contactor make further application appear promising. For example, a truly countercurrent fluidized bed for carrying out slow reactions (such as the hydrofluorination of UO_2) on a large scale might be practical in tapered reactors. Although outside the scope of the local application, the following nonreaction studies illustrate the practicality of such a process.

Fluid bed mixing

The mixing of UO_3, UO_2, and UF_4 was studied both in cylindrical and tapered units over a range of flow conditions. This mixing (at velocities 10-20% greater than minimum necessary for fluidization), expressed in units of diffusivity, was found to be greater than 4.0 sq. ft./hr. in cylindrical columns and less than 0.4 sq. ft./hr. in tapered columns. The analytical method is described in detail in separate literature (*6*). The model for mixing is based on the assumption that the bed is of constant density and that the column is radially homogeneous. The rate of component mixing can then be evaluated in terms of a coefficient in the dimensions of diffusivity. The coefficient is experimentally determined by measuring concentration changes with time at one extreme of a fluidized column. In one comparative test, cylindrical and tapered beds of UO_3, five inches in diameter and five feet deep at rest, were employed. UO_2 was fed continuously at the top and mixture was removed at the bottom such that the solids flow and constant bed weight were equal after 3.14 hours. The concentration of feed in product as a function of the turnover time (3.14 hr.) is shown in Figure 10. In addition to the experimental results, two additional lines of interest are shown. The upper dotted line presents the concentration time relationship for a totally mixed column (infinite diffusivity). The line to the lower right represents a column with no mixing (diffusivity zero) and this is often referred to as a "piston flow" contactor. Again, in considering the hydrofluorination of UO_2 and the retention time required for 99% conversion (2 hr.) the need for multistage contactors is clear. On the other hand, this could be achieved in a tapered column if the reaction occurred in less than thirty per cent of the turnover time.

Numerical analysis

While no studies in the presence of a reaction were made, a system is proposed for estimating the performance of large scale hydrofluorination units of minimum inventory. This was undertaken simply to explore any production advantage of a tapered unit over conventional cylindrical columns. To compute minimum inventory for a given production rate with fixed conversion and reagent efficiency, the kinetic rate data, heat transfer, fluidization velocity, mixing, and other experimentally determined data must be given. For the sample problem, previously tabulated results were utilized. Reagent gas-reacting solid equilibrium data must also be known as a function of temperature to estimate reagent efficiency, and the equilibria for this system have been studied and published by Kuhlman (*5*). The method represents the column volume in terms of the rate limiting processes and the minimum volume must satisfy all listed equalities.

The numerical representation is shown left.

The value δ in the cooling equation must be based on experience, and should include any safety factor needed in scaling from 5-in. diam. to 12 to 15-in. diam. In the equation concerning reagent supply, a minimum value for δ of 1.10 to allow inert

PROCESS	EQUALITIES†	
Process cooling	$DL = \dfrac{\delta q w}{\pi h \Delta t}$	(1)
Reagent supply	$D^2 = \dfrac{4\delta f}{\pi v(1-\epsilon)}$	(2)
Mixing	$D^2 L = \mathfrak{F}(M, k)$	(3)
Reagent efficiency	$D^2 L = \dfrac{4F}{r\rho k}\displaystyle\int_{x_b}^{x_t} \frac{dx}{x}\frac{1}{(y-y^*)}$	(4)
Column taper	$\tan\phi = \dfrac{D_t}{2L}\left[1-\left(\dfrac{1}{1+\dfrac{L\Delta p}{p_t}}\right)^{1/2}\right]$	(5)

† *Notation for dimensions.*

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gas flow for fluidization control is required. The maximum value for Δt was experimentally estimated to be 200°F.

The equality concerning mixing relates the experimentally determined mixing coefficient, the equivalent first order reaction rate constant, and given conversions (6) to the column volume by assuming that the mixing is constant throughout the column and proceeds independent of the reaction. It is further assumed that conversion can be expressed in terms of an equivalent first order rate constant. On this basis,

$$1 - c = \frac{4H}{\left[(H+1)^2 e^{\left(\frac{H-1}{2m}\right)}\right] - \left[(H-1)^2 e^{-\left(\frac{H+1}{2m}\right)}\right]}$$

where

$$H = (1 + 4mR)^{1/2} \qquad (6)$$

$$R = \frac{kL}{u}$$

$$m = \frac{M}{uL}$$

Although the column volume cannot be conveniently isolated in this expression, it is not difficult to develop by trial and error.

The reagent efficiency is related to the column volume by assuming the reagent transport proportional to a driving force $(y\text{-}y^*)$, such that $J = k(y\text{-}y^*)$, from which k is computed from thermobalance data. This expression is combined with the usual material balance information to obtain

$$LS = \frac{4F}{r\rho k}\int_{x_b}^{x_t} \frac{dx}{x}\left(\frac{1}{y - y^*}\right) \qquad (7)$$

which can be integrated over the column length to obtain

$$L = \left(\frac{4F}{Sr\rho k}\right)\frac{A}{C} \times \ln\left(\frac{C - Dx_b}{x_b}\right)\left(\frac{x_t}{C - Dx_t}\right) + \frac{B}{D}\ln\left(\frac{C - Dx_t}{C - Dx_b}\right) \qquad (8)$$

where

$$A = Gy_b + 2Fx_b + I$$

$$B = 2F$$

$$C = Gy_b + 4Fx_b - y^*(Gy_b + 2Fx_b + I)$$

$$D = 4F - 2Fy^*$$

From an evaluation of each of the groups, minimum column dimensions necessary to satisfy all the criteria can be determined. In cases where temperature zoning will further reduce the inventory, this minimum can also be developed by iterative procedure. Based on the methods described, it may be shown (6) that a sixteen foot column, 1.13 ft. in diameter at the bottom and 1.26 ft. in diameter at the top, would produce 1000 lb./hr. UF_4 at 99% conversion, utilizing 95% of the reagent gas. This countercurrent column would operate with 20-40 mesh UO_2 entering at 400°F. and product UF_4 exiting at 1050°F.

NOTATION

- D = column diameter, ft.
- F = feed rate of solids reactant, lb. mol/hr.
- G = total molar gas flow, lb. mol/hr.
- I = inert gas flow, lb. mol/hr.
- J = transport of reactant gas (HF), lb. mol/(hr.) (sq. ft.)
- L = active bed depth of column length, ft.
- M = mixing coefficient for fluidized solids (diffusivity), sq. ft./hr.
- R = fluidized bed superficial surface area, sq. ft./cu. ft. column
- S = column cross sectional area, sq. ft.
- V = column volume, cu. ft.
- c = fractional conversion of feed to product, dimensionless
- e = fractional bed expansion from rest to fluidized state, dimensionless
- f = reagent gas flow, outlet conditions, to supply stoichiometric requirement, cu. ft./sec.
- h = heat transfer coefficient, powder to vessel wall, Btu/(hr.) (sq. ft.) (°F)
- k = equivalent first-order reaction rate constant, $hr.^{-1}$ (result of thermogravimetric measurements)
- p = total pressure at any point, lb./sq. in. abs.
- Δp = bed pressure drop, lb./sq. in./ft. bed
- q = heat release due to reaction, Btu/lb. feed
- r = superficial surface area of reactant, sq. ft./lb. mol
- t = temperature, °F
- u = superficial solids velocity, ft./hr.
- v = superficial gas velocity for fluidization, ft./sec.
- w = solids feed rate, lb./hr.
- x = mol fraction uranium, solids
- y = mol fraction reactant, gas
- y^* = mol fraction reactant gas at equilibrium
- t, b = subscripts (indicate top and bottom of fluidized bed)
- ϵ = bed void volume at rest, dimensionless
- ρ = bed density in action, lb./cu. ft.
- μ = gas viscosity, consistent units
- ϕ = column taper measured as the angle included between the column wall and vertical line
- δ = a constant, experimentally determined (see text)

LITERATURE CITED

1. Levitz, N. M., *et al*, "A Fluidized Bed Process for the Production of UF_4", *Chem. Eng. Progr.*, *53*, 199, (1957).
2. Szulinski, M. J., *Chem. Eng. Progr.*, *53*, 586, (1957).
3. Levey, R. P., Jr., "Development in Porous Metal Media for Gas Filtration", Union Carbide Nuclear Co., Report No. Y-1235, (Feb., 1959).
4. Orrick, N. C, "Hydrogen Reduction Rates of Uranium Trioxides As Obtained With A Thermobalance", Union Carbide Nuclear Co., Report No. K-1081, (Dec., 1953).
5. Kuhlman, C. W., "Equilibria In The System UO_2-HF-H_2O", Mallinkrodt Chem. Works, Report No. MCW-112, (Apr., 1959).
6. Levey, R. P., Jr., *et al*, "Development of A Continuous Countercurrent High Efficiency Gas-Solids Contractor", Union Carbide Nuclear Co., Report No. Y-1233, (Oct., 1958).

FRANK T. BARR AND WILLIAM P. DREWS

The future for cheap heavy water

Eight promising methods for producing heavy water are spotlighted from this survey of ninety eight processes.

Containment vessel for the Heavy Water Components Test Reactor at Savannah River under constructon.

THIS CONDENSED REPORT of work done by Esso Research and Engineering Company on a survey for the U. S. Atomic Energy Commission presents alternatives to existing methods for manufacture of heavy water (*1*).

In this survey almost 100 ideas were considered and tabulated in Table 1. On preliminary examination most were determined to have little or no prospect for economic development, and the comments in Table 1 comprise the only discussion given them in this article. For processes of which more than preliminary examination was made, the target for comparison was dual-temperature H_2S/H_2O exchange.

Established methods of heavy water production were not included: water distillation; hydrogen distillation; single-temperature hydrogen / water exchange with electrolytic regeneration of enriched hydrogen (Trail Plant); "conventional electrolysis"; and hydrogen/ammonia high pressure dual-temperature exchange. These have been discussed elsewhere (*3, 4, 5*).

The basis for evaluation used in the survey needs emphasis; only initial, or first stage concentration was evaluated, since the cost of other stages would be small; potential processes were given the benefit of optimistic interpretation of available or projected data and of construction costs which might be met in putting them into practice.

The study did not develop great hope for significant reduction in cost of D_2O manufacture; as the survey proceeded the probability of making striking reductions in cost became more remote. Although significant savings may possibly still be realized, either by revision of existing processes or by development of new processes, they are likely to be only moderate and their realization would require considerable development work.

The reasoning which led to the conclusions of Table 1 cannot be given in detail. However, the information on which they are based is indexed in the bibliography (*2*). Eight of the processes are discussed more fully below.

The first large-scale manufacture of heavy water began at Trail, B.C., in June, 1943, using the isotopic exchange principle. This plant employed existing electrolytic hydrogen facilities to convert water from the exchange tower to hydrogen to be scrubbed by the water coming down the tower (*6*). Except where such facilities are already available, the cost of converting enriched water to an exchangeable hydrogen-containing gas is excessive, and dual-temperature exchange, which does not require this step, has generally supplanted "single-temperature" exchange (*7*).

Over half of the processes covered by this survey are exchange systems which could be used in dual-temperature operation. The H_2S/H_2O system is now commercially applied in dual-temperature plants by AEC, as described by Bebbington and Thayer (*8*). Their figures are used in developing the H_2S/H_2O system costs shown in Table 2. A total cost of $26.41/lb. of D_2O, allowing 8% on total investment for depreciation and ad valorem taxes, results from their information. This is close to the $28/lb. selling price used by AEC, so that these figures represent a reliable evaluation of the cost (excluding return on investment) of heavy water

Table 1. Potential processes examined

Process Number*	Process Name	Comments
	Chemical Exchange Processes (See also Processes Nos. 55-80, 95, 96, 98)	
1	Hydrogen/water dual-temperature exchange (Process A in text)	Might have good potentiality if the exchange could be made to go fast enough. No promising adaptations so far.
2	Ammonia/hydrogen dual-temperature exchange (See Ref. 5)	Independent study made of this system. No advantage over the H_2S/H_2O process.
3	Phosphine/water dual-temperature exchange (Process C in text)	Reaction rate probably too low, but separation efficiency higher than that of the H_2S/H_2O process.
4	Diborane/hydrogen exchange	Separation factors for this system not known. Unless it has unusual characteristics it will not be outstanding because of the high refrigeration load.
5	Hydrogen sulfide/water dual-temperature exchange (See text)	Target for comparison. See also Process No. 98.
6	Methane/hydrogen exchange	Exchange data on all *(2)* show low reaction rate, extensive decomposition, or both. However, incentive for such a process is great since methane in natural gas is the largest single source of hydrogen next to water.
7	Ethane/hydrogen exchange	
8	Propane/hydrogen exchange	
9	Butane/hydrogen exchange	
10	Isobutane/hydrogen exchange	
11	Cyclohexane/benzene-hydrogen exchange	Involves isotope exchange equilibria in a hydrogenation-dehydrogenation reaction. Slow rates and high heat of reaction probably make it not economical.
11A	Cyclohexane or benzene/hydrogen exchange	Avoids the high heat of reaction, but quick, easy equilibration not expected.
12	Glycol/water exchange	Separation factor close to unity at all temperatures.
13	Aromatics/ammonia exchange	Separation factor probably low.
14	Acetone/hydrogen exchange	Separation factor probably good, but exchange rate low.
15	Mercaptan/water exchange	Suggested during the 1941-45 development work. No new information obtained. The process might still be attractive.
16	Enols and ketones/hydrogen exchange	Separation factors probably good, but exchange rates low.
17	Potassium amide/hydrogen and substituted amines/hydrogen exchange	Expected to have about the same separation factor as the ammonia-hydrogen system. Choice of the proper amine substituent may avoid the high vapor pressure associated with ammonia, which makes high-pressure operation necessary. See also Process No. 95.
18	Ion-Exchange resin/water exchange	Separation factor likely to be poor.
19	Thorium hydride/hydrogen exchange	Exchange rate probably too slow to be of interest.
20	Potassium hydride/hydrogen exchange	
21	Sodium hydride/hydrogen exchange	
22	Cesium hydride/hydrogen exchange	Slow exchange rate; inventory costly and limited.
23	Rubidium hydride/hydrogen exchange	
24	Uranium hydride/hydrogen exchange	Exchange apparently rapid, and countercurrent fluid solids tower could be used. However, large inventory would be expensive, and the separation factor probably not exceptionally good. See also Process No. 96.
25	Gadolinium hydride/hydrogen exchange	Separation factor probably low. Supply of Gd and Ce limited.
26	Lithium hydride/hydrogen exchange	
27	Cerium hydride/hydrogen exchange	
	Once-Through Decomposition Reactions	
28	Decomposition of water by alkali metals	Generally unsuited to tower or cascade operation. Some might be useful for concentration of feed to existing operation. See Process No. 88
29	Decomposition of water by calcium carbide	
30	Decomposition of water in methane-steam reforming	
31	Bacteriological decomposition and utilization	
	Processes Involving Electrolysis (See also Processes No. 83 and 84)	
32	Lowering overvoltages in an electrolytic process by the use of solutes	Could improve electrolytic process which already looks good, but would not make unattractive process economic. Probability of success low.
33	Reoxidizing hydrogen with metallic oxides to make pure metal byproducts	Secures byproduct credits for an electrolytic process, but limited by metals production rate.
34	Electrolysis through osmotic diaphragm	Considered in connection with Process No. 83.
35	Trail-type operation at electrolytic chlorine plants	Somewhat less attractive than the Trail operation, which does not compete with large scale H_2S/H_2O plants.

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production with which any new process must compete.

It became apparent that a simple, approximate method of evaluating dual-temperature exchange systems would be desirable. Accordingly, the following procedure for use in comparing new gas/liquid systems with the target H_2S/H_2O was developed.

Dry cross section

In high-enrichment deuterium separation systems the recovery from the feed is equal to the concentration in the feed less the concentration in the waste divided by the concentration in the feed. In dual-temperature exchange systems, pure component separation factors determine the waste concentration theoretically available, as shown in the idealized flow plan of Figure 1.

Accordingly, theoretical maximum recovery may be expressed:

$$R=(\alpha_c-\alpha_h)\,/\,\alpha_c$$

The amount of feed multiplied by the fractional recovery equals the amount of product (in terms of material of feed concentration), or:

$$P=RL \qquad P/L=R$$

where: R=fraction of inlet deuterium recovered in product stream

α=separation factor, atomic ratio of $D/(D+H)$ in pure liquid component divided by that in pure vapor component, at equilibrium

P=product deuterium withdrawal rate, in terms of equivalent feed

L=liquid feed rate

and the h and c subscripts refer to the hot and cold towers. These equations fix the minimum amount of feed required per unit of deuterium recovered.

In the dual-temperature system, the amount of gas circulated must carry about the same amount of deuterium as does the liquid being circulated countercurrent to it at any given level in the towers. This must be so because the amount of deuterium involved in the build up of concentration along the towers is many fold greater than the net transport into the product. This situation can be analyzed rigorously by consideration of a McCabe-Thiele type diagram of the operation, as exemplified in Figure 2. This shows that the ratio of deuterium concentration in the gas phase to that in the liquid phase at the high concentration end of both towers will be about the average of the separation factors for the two towers.

Therefore, the average molal ratio of pure gas to pure liquid flow will be the mean of the separation factor, or:

$$G/L=(\alpha_c+\alpha_h)/2$$

The total amount of gas circulated per unit of product will be proportional to the quotient of these two ratios. The "dry cross section" of the towers is therefore the following:

Dry cross section =

$$K \times \frac{G}{P} = K \times \frac{(\alpha_c+\alpha_h)/2}{(\alpha_c-\alpha_h)/\alpha_c}$$

Using this as a measure of cross section required assumes that superficial linear vapor velocities are the same for all systems at a given pressure and that percent approach to theoretical recovery is constant.

Wet cross section

The above formula gives comparable cross sections so long as the effects of gas solubility in the down-flowing liquid and of vaporization of liquid in the up-flowing gas can be neglected. When this cannot be done, allowance for the additional vapor volume must be made. The effect of solubility and vapor pressure is not on theoretical recovery, but on the size of towers necessary to handle the gas. The so-called "wet cross section" of the towers can be derived from the "dry cross section" as follows.

The volume proportion of dry gas, n, in the vapor flowing up the tower is equal to $(\pi-p)/\pi$, where p is the liquid vapor pressure and π the total pressure under the conditions of operation. Using m as the molal ratio of dissolved gas to the liquid component in the down-flowing liquid phase at the tower conditions, the total volume of gas plus vapor, V, is related to the basic gas flow, G (defined above), as follows:

$$V = \frac{G}{n}\left[1+\frac{2m}{(\alpha_c+\alpha_h)}\right]$$

For purposes of comparison, it is assumed that the wet cross section will be proportional to the amount of gas plus vapor so calculated.

Adjustments to firm up the relations developed above will be obvious, but for this simplified comparison the only correction made was for the effect of pressure. Taking into account the effect of operating pressure on gas volume, vessel wall thickness, and allowable gas velocity; tower material requirements can be taken as roughly proportional to the square root of the pressure. However, vessel wall thicknesses do not decrease below the pressure at which vessel stiffness and corrosion allowances become controlling, and the square root relation should not be used below about three atmospheres pressure.

Normally, operation of the hot and cold towers will be carried out so as to require about the same number of plates in each. The effect of separation factor on the number of plates required in a tower can be approximated from countercurrent extraction relations developed by Underwood and others (9):

$$\text{No. plates} = k/\log \alpha_c/\alpha_h$$

Table 3 gives a group of calculations using the techniques described above. The results are in terms of tower cross section, with correction shown to reflect the effect of pressure on relative tower weight per plate. Without the pressure correction, the dry cross section figures measure the dry-gas circulation needed; the wet cross section figures coupled with the temperature difference between the hot and cold towers are related to the sensible heat exchange duty required in the system. Within the limits of its reliability the method may be used for finding optimum conditions, as well as for making comparisons between systems.

Table 2. Cost of production of heavy water by H_2S/H_2O dual-temperature exchange (8).

Onsite Investment	Per Ton/Year
(500 ton/year plant)	$230,000
Offsites, incl. Utilities	95,000
Total	$325,000

Operating Costs	Per Pound of D_2O
Salaries and Operating Labor	$1.30
Miscellaneous Supplies	.15
Feed Water	.40
Hydrogen Sulfide	.35
Direct Maintenance	
Labor	1.32
Material	.49
Utilities	
Electricity	1.33
Steam	4.40
Miscellaneous	.18
Total Direct Cost	$ 9.92
Overhead	3.49
Depreciation and Taxes at 8% on $325,000/ton/year	13.00
Total, incl. Deprec.	$26.41

Promising processes

A. Hydrogen/water exchange. A process thought to have possibilities was dual-temperature hydrogen/water exchange in so-called Barr towers (6).

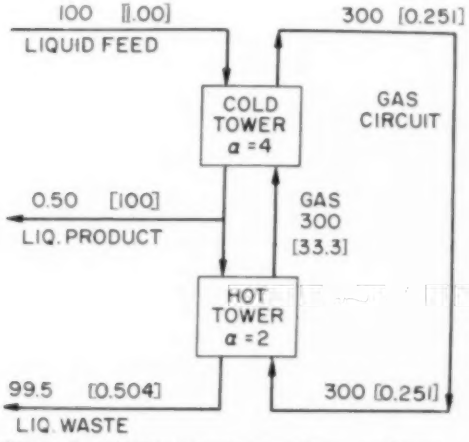

Figure 1. Idealized dual-temperature exchange with flows expressed in atoms of exchangeable hydrogen. Deuterium conc. shown in brackets are relative to arbitrary value of unity in feed.

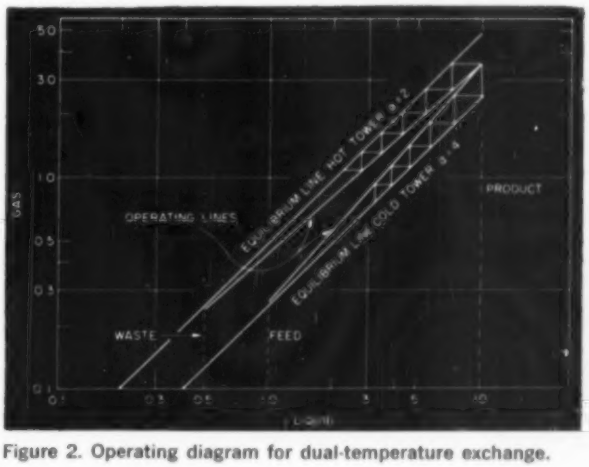

Figure 2. Operating diagram for dual-temperature exchange.

Table 1. Potential processes examined (continued)

36	Simple reversible electrolysis	Little promise for the originally proposed process using two liquid phases. See process No. 83.
	Adsorption Processes (See also Processes Nos. 85-88)	
37	Hydrogen on palladium	Inventory costs too high.
38	Hydrogen on platinum	
39	Hydrogen on platinum reforming catalyst	Detailed study of the char system (Process No. 44) made. (Progress Report No. 2 of Ref. 1), but not reported in this paper. General conclusion was that H_2 adsorption systems might be attractive if good separation factor obtained without going too low in temperature but that reaching this goal is unlikely. Char system would require separation factor of at least 100 at -400°F, or 50 at -260°F.
40	Hydrogen on hydroforming catalyst	
41	Hydrogen on aromatizing catalyst	
42	Hydrogen on alumina	
43	Hydrogen on silica gel	
44	Hydrogen on char	
45	Liquid-liquid extraction of water	Triethylamine was attractive solvent but separation factor and mass transfer rate were low.
46	Liquid nitrogen absorption of hydrogen	Other work was to be done in this field, so no evaluation made.
	Diffusion Processes	
47	H_2 diffusion through porous barrier	No evidence that any of these processes would be attractive. Successful application of diffusion separations has been to more valuable materials, with higher starting concentration (*e.g.* U-235).
48	H_2 diffusion through vapor barrier	
49	Thermal diffusion (Clusius-Dickel)	
50	Ion diffusion through exchange resin	
51	Liquid thermal diffusion	
52	Hydrogen diffusion through palladium	
	Distillation Processes (See also Processes No. 90-94, 97)	
53	Rotating-cone column for low pressure drop in water distillation	Water distillation excluded from this study, but idea might be useful for maintaining good separation factor by low pressure.
54	Falling-drop condensation in hydrogen distillation	To control fouling of exchangers by CO ice, but technique not necessary if reversing exchangers perform satisfactorily.
	Additional Exchange Processes	
55	Benzene/hydrogen chloride exchange	Exchange rate and separation factor low.
56	Enols and ketones/water exchange	Separation factor probably close to unity.
57	Alizarin/hydrogen exchange	Separation factors about same as in ammonia/hydrogen system. The lower vapor pressures might help if exchange rates were good.
58	o-Anisidine/hydrogen exchange	
59	o-Toluidine/hydrogen exchange	
60	Dimethylglyoxime/hydrogen exchange	Separation factor no better than for water/hydrogen system.
61	Hydrogen chloride/hydrogen exchange	Poor separation factor.
62	Indole/water exchange	Separation factors about same as for ammonia/water exchange, which is close to unity.
63	Methyl indole/water exchange	
64	Pyrrole/water exchange	Separation factors for these systems also probably small.
65	Indene/water exchange	
66	Hydrogen sulfide/methyl alcohol exchange	Avoids hydrate formation problems in H_2S/H_2O system, but these apparently not serious. No improvement in exchange efficiency.
67	Amyl alcohol/water exchange	Separation factor close to unity.
68	Methyl alcohol/water exchange	
69	Ethanethiol/water exchange	Separation factor about same as for H_2S/H_2O system.
70	Nitrophenol/water exchange	Separation factors expected to be low.
71	Phenol/water exchange	
72	Resorcinol/water exchange	
73	Sugars/water exchange	
74	Vinyl acetic acid/water exchange	
75	Acetylene/water exchange	Separation factors for these base-catalyzed reactions expected to be low.
76	Chloroform/water exchange	
77	Complex cobalt and copper-ammonia salts/water exchange	Between water vapor and a water solution of the salt. Separation factors probably low.
78	Aniline hydrochloride/water exchange	Low separation factors expected.
79	Mono- and dimethylamine hydrochloride/water exchange	
80	Halogen acid/water exchange (Process D in text)	Not economical unless solubilities and humidities obtainable can be demonstrated to be much lower than assumed in this study.
81	Sodium sulfate decahydrate/water exchange	Negligible separation effect.

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These towers adapt vapor phase hydrogen/steam exchange to countercurrent operation, and work most effectively under conditions that put roughly equal amounts of water and hydrogen in the feed to each vapor phase exchange. However, much larger vapor rates and hence larger tower diameters would be anticipated for this system than in the hydrogen sulfide / water system, and it cannot be considered an improvement. (Note that the calculation method used in Table 3 does not apply directly to systems using Barr towers.)

Simplification of the exchange tower design would result if a fast hydrogen / liquid water exchange, with a good homogeneous catalyst, could be developed. This situation is essentially that postulated for the hydrogen/water-hydrazine process discussed in the next section.

B. Hydrogen/water-hydrazine. Inorganic amides are catalysts for ammonia exchange with hydrogen. If hydrazine were to have similar effects on water, it might be useful as a bridge between liquid water and hydrogen. Hydrazine is very soluble in water and has vapor pressure characteristics reasonably close to those of water.

With the possibility that this type of catalysis might be effective, the potential improvement in the hydrogen / water system over the H_2S/H_2O system becomes more attractive. Very roughly, tower cross sections equivalent to three-quarters those of the H_2S operation might be required, and a saving of perhaps half in the number of theoretical plates be expected. Calculations for this case are shown in Table 3, using the technique described in the section on dual-temperature systems for evaluation.

This simplified evaluation indicates that some exploratory investigation of the hydrogen / hydrazine-water reaction is needed. Both rate of bubble tray equilibration and exchange equilibrium constants should be checked. If hydrazine itself did not turn out to be sufficiently effective, the use of a substituted hydrazine could be explored.

C. Phosphine/water. The fundamental advantage for a dual-temperature system based on gaseous phosphine and liquid water lies in the fact that compared to the H_2S/H_2O system, 50% more hydrogen is carried per volume of gas. There is a slight disadvantage in temperature coefficient, so that the overall decrease in tower cross section is in the order of 25%. The primary prob-

lem in this system lies in the rate of exchange, which so far has not reached the order of magnitude of the rate achieved by H_2S/H_2O. While the phosphine / water system is both acid and base catalyzed, rates obtained at reasonable levels of acidity or alkalinity are too low to give satisfactory bubble plate efficiency (*10*).

However, some calculations were made on the assumption that conventional bubble tray contacting would be suitable for getting high efficiency countercurrent exchange. Results are shown in Table 3. It is seen that a successful PH_3/H_2O system would allow operation of a given plant at 30-40% greater capacity than the H_2S/H_2O system. One of the most attractive potential adaptations of the phosphine process, if the low exchange rate problem can be solved, is the possibility of its use in an existing H_2S plant. Provision to increase liquid flow rate would have to be made but this should be small compared to that necessary for increase of the gas rate.

D. Hydrogen iodide/water. Dual-temperature exchange using a hydrogen halide / water system was given comprehensive study. Investigation of the characteristics of the HCl, HBr, and HI systems led to the conclusion that hydrogen iodide would be the most attractive adaptation from a technical viewpoint. Because of its ionic nature, this system should approach equilibrium quickly and allow use of bubble plate exchange columns.

To avoid relying only on the simplified evaluation technique, a moderately detailed process study of this system was made. Indications were that the process would be definitely more expensive than the target. The design worked up was estimated to require about 600 theoretical plates to reach 1% D_2O, compared to about 200 for the H_2S/H_2O process (*8*). The use of a common ion solute to destroy the HI/H_2O azeotrope and reduce solubility of the HI in water was postulated.

Application of the simplified evaluation technique to the HI/H_2O system also showed the process as postulated less attractive than H_2S/H_2O dual-temperature exchange. The data in Table 3 show that tower cross sections required are significantly larger, and heat loads would show even greater difference. The main cause for the poor showing is that HI carries only half as much

continued on next page

Table 3. Relative tower requirements for dual-temperature exchange systems.

System	H_2S/H_2O		$H_2/H_2O.(NH_2)_2$			PH_3/H_2O	HI/H_2O
Oper. Press., Atm.	18	8	18	18	10	18	3
Cold Tower, °F.	86	86	86	86	86	86	86
Hot Tower, °F.	266	266	266	302	302	266	176
Fractionation Factor							
Cold Tower	2.18	2.18	3.77	3.77	3.77	2.26	3.43
Hot Tower	1.82	1.82	2.47	2.35	2.35	1.92	2.82
Theoretical Recovery	16.5%	16.5%	34.5%	37.6%	37.6%	15.0%	17.8%
Relative No. Plates	100	100	43	40	40	111	93
Relative Dry C.S.*	100	100	76	68	68	77†	290††
Cold Tower							
Liq. Vap. Press., Atm.	0.042	0.042	0.042	0.042	0.042	0.042	0.04
Gas Solubility**	0.0016	0.0016	—	—	—	0.0002	0.237
Rel. Wet C.S.	102	101	76	68	68	77†	360††
Hot Tower							
Liq. Vap. Press., Atm.	2.67	2.67	2.67	4.70	4.70	2.67	0.58
Gas Solubility**	0.0006	0.0006	—	—	—	—	0.107
Rel. Wet C.S.	119	150	89	92	128	90†	390††
Pressure Correction							
Factor	4.25	2.83	4.25	4.25	3.16	4.25	1.73
Avg. Wet C.S.	110	126	83	80	98	83	375
Corr'd Effective Wet C.S.	468	355	350	340	310	350	650
Same, Relative to Target	100	76	75	72	66	75	139

* *Dry cross section taken same for both towers; no adjustment made for effect of temperature on dry gas rate.*

** *Mols gaseous component per mol liquid component at one atm. pressure of gaseous component.*

† *After ¾ correction for PH_3 molecule carrying three atoms hydrogen.*

†† *After doubling correction for HI molecule carrying only one hydrogen atom.*

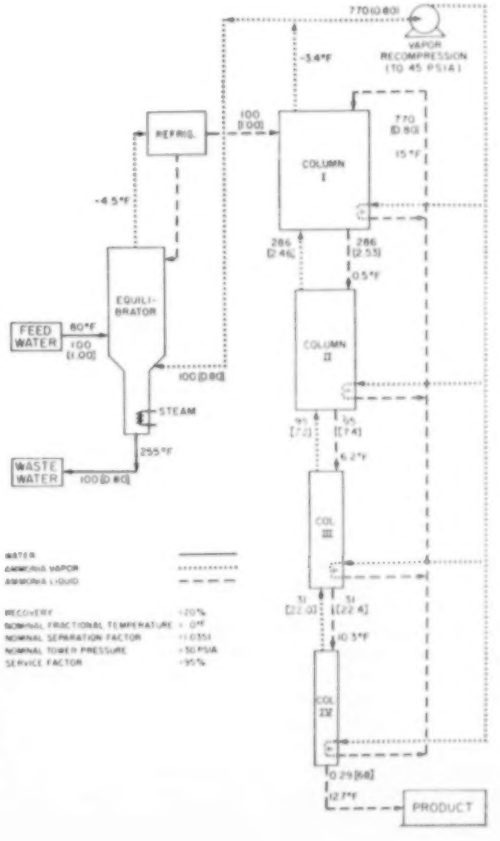

Figure 3. Simplified schematic flow diagram for ammonia distillation. Flows are expressed in atoms of exchangeable hydrogen while deuterium concentrations shown in brackets are relative to arbitrary value of unity in feed.

Table 1. Potential processes examined (continued)

	Partially Concentrated Sources (See also Process No. 88)	
82	Hydrogen residues from hydrogenation	No great possibilities seen for this system. Hydrogen throughput unlikely to be large enough to give a considerable production of deuterium.
	Additional Electrolysis Processes	
83	Diaphragm-separated reversible electrolysis (Process F in text)	Little hope for making an economical process of this system. However, the idea is of considerable technical interest.
84	Direct electrolytic release of deuterium (Process G in text)	Could be attractive if a separation factor of 10 or better were demonstrated for the preferential release of deuterium. Might be achieved by using pulsating direct current at a deuterium ion resonance frequency.
	Additional Adsorption and Absorption Processes	
85	Adsorption of hydrogen on nickel	Conclusions of the study on Process No. 44 are pertinent. However, refrigeration would not be required.
86	Adsorption of hydrogen on calcium	
87	Adsorption of water on silica gel	Water adsorption on char may have favorable application as feed water concentrating process.
88	Adsorption of water on char (Process H in text)	
89	Hydrogen absorption in water	Separation factor expected to be low.
	Additional Distillation Processes	
90	Dual-temperature water distillation	Vapor recompression is more economical method of heat conservation.
91	Methane distillation	Less attractive than ammonia distillation (Process No. 94).
92	Silanes distillation	Not attractive without unusually good separation factors. Feed would have to be by equilibration with water, satisfactory form of which is not readily apparent.
93	Hydrogen fluoride distillation	
94	Ammonia distillation (Process E in text)	Could be distinctly superior to water distillation, but this depends on confirmation of anomalous vapor pressure of NH_2D.
	Additional Exchange Processes, etc.	
95	Hydrazine-water/hydrogen exchange (Process B in text)	Has promise. Separation factor of the order of the H_2O/H_2 and the NH_3/H_2 systems. Presence of hydrazine or substituted hydrazine might give useful exchange rates. See also Process 17.
96	Titanium hydride/hydrogen exchange	Reported to have reasonably good separation factor. Fluid solids exchange tower could be used. See also Processes Nos. 19-27.
97	Zone-melting of water	Zone melting is the solid/liquid analog of batch distillation. No possibility of economical application seen.
98	Liquid-liquid hydrogen sulfide/water exchange	Study indicated that liquid/liquid hydrogen sulfide/water exchange could not compete with the present vapor/liquid process.

**The numbering system of this table is the same as used in the original reports to AEC (1, 2)*

hydrogen per molecule as does H_2S, and therefore all gas flows are doubled.

E. Ammonia distillation. Both water and hydrogen distillation have been thoroughly investigated, the former in production-scale plants, the latter in detailed design study (*11*). Distillation of ammonia has the advantages of good vapor pressure, low latent heat, and good relative volatility compared to water at the same pressure. The relative volatility for the NH_3-NH_2D system, calculated using the geometric mean rule for vapor pressures of partially deuterated ammonias (*12*), ranges from 1.0437 at −30°F and one atm. vapor pressure to 1.0212 at 70°F and 8.5 atm.

In addition to the above indicated advantages, Stedman (*13*) has suggested that the monodeuterammonia may have a vapor pressure lower than that predicted by the geometric mean computed from NH_3 and ND_3. This would be very useful in the concentration of deuterium, since the most expensive part of the separation is that carried out in the low concentration range, where vapor pressures of NH_3 and NH_2D control the separation. This question should be investigated experimentally, since if the anomaly really exists, plant costs might be reduced to perhaps half the amounts shown in this study.

A simplified process flow plan is shown in Figure 3. The basic design was set up to obtain feed by countercurrent equilibration with water. The plant operates at a 0°F nominal fractionation temperature, which gives relative volatility of 1.0351 for NH_3/NH_2D. The deuterium recovery is 20%. Vapor recompression is used to provide reboiling and condensation.

Table 4 summarizes economic comparisons with the target process. The base case plant uses equilibration feed and shows operating costs over twice the target. Consideration was also given to the possibility of feeding ammonia directly in a parasitic-type operation at ammonia production plants. The elimination of the equilibrator cuts the cost somewhat, but does not make the process competitive. The optimistic case uses very favorable assumptions relative to possible cost reduction due to design optimization (15%), steam cost ($.30/1000 lb.), and cooling water costs ($17.50 investment/gal./min.), but still does not quite reach the target.

This leaves the possibility that the relative volatility at low concentrations may be a good deal more favorable than was assumed. Although a detailed study of the effect of better separation factor was not made, it would be felt throughout the plant. If the anomaly were as great as suggested by Stedman (*13*), *i.e.*, if $\alpha - 1$ were doubled, requirements in the major portions of the plant, reboiling duty, reflux rates, vapor flows, *etc.*, could be reduced by as much as one-half.

F. Reversible electrolysis of water. Although it can be shown to be economically attractive only with unrealistically optimistic assumptions, this process is of considerable interest because of the novel technical ideas involved. It was investigated as a means of making use of the large separation factor in electrolysis, without paying the large power consumption penalty associated with complete electrolysis of water. It was hypothesized that this could be accomplished by arranging a cell to carry out a reduction reaction involving hydrogen ion at the cathode and an oxidation reaction involving water at the anode. Thus, the cathode reaction would reduce a compound having two oxidation states, and would convert hydrogen ion to water. The anode reaction would reoxidize the same compound, and convert water back to hydrogen ion. This cell would have a reversible voltage of zero,

Table 4. Economics of ammonia distillation.

	Base Case	Parasitic Plant	Parasitic Plant Optimistic	Target H_2S/H_2O D. T. Exch.
Investment, $/Ton/Yr. D_2O	$365,900	$290,000	$250,000	$250,000
Operating Costs, $/Lb. D_2O	$63	$41	$30	$28

but it would still involve the discharge of hydrogen ions, which is the step thought to give the separation. Figure 4 shows the schematic setup of the process proposed.

It was expected that the separation would occur when hydrogen ions are discharged on the surfaces of diaphragms interposed in the direction of the current flow. These diaphragms are made of thin sheets of palladium or other material permeable to atomic hydrogen. The atoms diffuse through the diaphragm and are reionized by anodic action on the other side. Study of separation mechanisms indicates that deuterium will lag also in the diffusion step, and preliminary work at Oak Ridge (*14*) has indicated that deuterium lags in the reionization step as well. The ionic flow is from right to left in the drawing, which is countercurrent to a left-to-right liquid flow through the successive chambers. It is this liquid flow which carries the progressively concentrated material to the product side of the apparatus and comprises the forward flow.

It is therefore anticipated that large separation factors might be obtained in this type of operation. This suggests a sharply tapered cascade, and such tapering was actually used in the economic analysis. The analysis was based on a separation factor of ten, but the most optimistic assumption (relative to compounding of separation factors in the various transport steps) might lead to a factor as large as thirty.

However, in spite of the greatly lowered voltage of a reversible cell reaction, estimated as low as 0.15 volts overall, the process was not attractive. The current needed for a 40 ton/hr. plant designed for 75% D_2O recovery at 1% concentration is in the range of 100 million amperes. The oxygen backflow using an oxidizing compound which will be reduced in preference to the H^+ ion poses a serious problem in selecting a suitable material and in handling its return. The diaphragm material would be costly, even if an iron or nickel substitute for high-priced palladium could be developed.

The potential economics of this process, estimated optimistically throughout, showed it no better than competitive with existing processes. Outstanding costs, for example, were those for power and electrodes. These are shown in Table 5, and amount by themselves to almost $26/lb. of D_2O. Since oxide separation and return equipment, power distribution, etc., would certainly add costs of serious magnitude, this process could hardly have economic advantage over the H_2S/H_2O process target cost of $28/lb.

G. Direct electrolysis of deuterium. Electrolysis normally releases hydrogen in preference to deuterium. This fact has serious implications as far as process economics are concerned; both power costs and electrode area are directly related to the quantity of material being released, and the hydrogen/deuterium ratio in normal water is about 1/7000. Since there was some thought that conditions might be found to give preferential release of deuterium by electrolytic means (*15*), the possible economics of such a process were looked into.

Review of possible designs for such a process showed that the potential savings are impressive. If the process could be developed to give deuterium of 10% purity or better in a single stage (which would require a separation factor of 700 or more, depending on the recovery), the costs might be less than half of those for existing processes. Even if the separation factor were as low as 10, a deuterium-selective electrolytic process could be competitive with existing processes, provided that power costs could be reduced by some technique like that of the reversible electrolysis system previously discussed. The power costs in this plant might amount to as little as $1.25/lb. of D_2O at 0.5¢/KWH. The electrode area is reduced from 14.6 million sq. ft. in the reversible electrolysis design to 2.3 million. The portion of operating costs which

Table 5. Partial costs for reversible electrolysis.

Plant Capacity, Tons D_2O/yr.	40
Investment	
Plant Cost, based on electrode area only, @ $0.60/sq. ft.	$9,000,000
Same, per Ton/yr.	225,000
Target, per Ton/yr.	250,000
Operating Costs	Per Pound D_2O
Power, @ 0.5¢/KWH	$8.18
Plant Operation, incl. depr.	17.50
Total	$25.68
Target H_2S/H_2O D.T. Exch.	$28.00

Table 6. Vapor-liquid separation factors* in water.

Temperature, °F	Char Adsorption	Distillation
86	1.8	1.07
212	1.214	1.025

*$(HDO/H_2O)_{liq}/(HDO/H_2O)_{vap}$

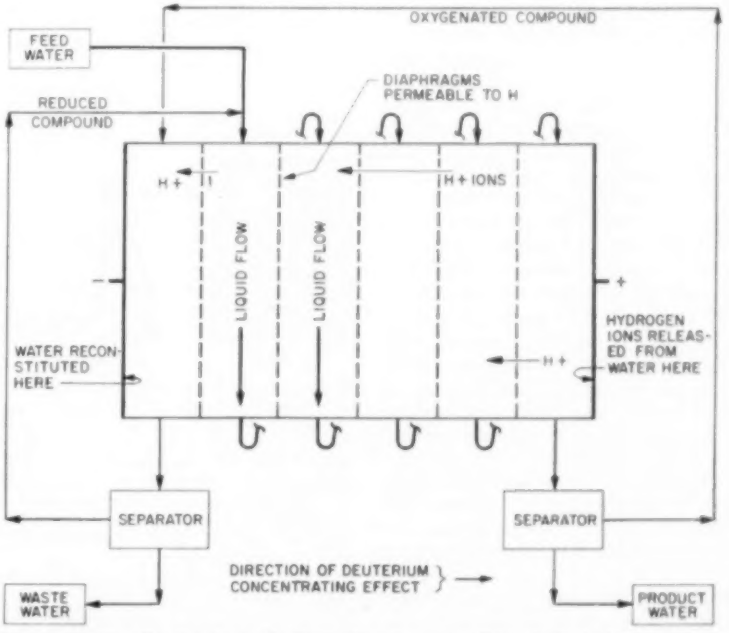

Figure 4. Simplified schematic flow plan for reversible electrolysis of water.

might be attributed to electrode cost, at 60¢ investment/sq. ft. amounts to about \$2.80/lb. D_2O. An additional cost of \$1.80/lb. D_2O might be incurred if feed pretreatment were necessary. These figures exclude return on investment and should be compared with the \$13.41/lb. D_2O shown in Table 2 for the target process.

No proven technique has been found for obtaining deuterium-selective electrolysis. However, one suggestion which was developed has to do with the use of an ionic resonance phenomenon to obtain selective discharge of deuterium ions (*15*). This suggestion is based on the postulate that each ion in the immediate vicinity of the cathode of an electrolytic cell, acted upon by a force field consisting of the cell potential plus the forces corresponding to the overvoltage, should form a system capable of exhibiting resonant behavior to oscillating potentials. The forces acting on the deuterium and hydrogen ions are, of course, very nearly the same. However, the masses are different, and hence different resonant frequencies would be expected.

The supposed ionic resonances would be used by imposing upon a cell a D.C. potential just insufficient to cause release of hydrogen. Upon this would be superimposed an A.C. potential of the proper frequency to excite deuterium ions, but not hydrogen ions. The amplitude of the A.C. potential would be adjusted such that at the peak of each cycle, a certain number of deuterium ions would be excited to the discharge point. Preliminary information indicated that the resonant frequencies would be very high—perhaps beyond the reach of commercial-scale generating equipment—possibly even beyond the reach of the laboratory.

No laboratory evaluation of this proposal is available, but the results of these analyses suggest that any leads toward obtaining a preferential release of deuterium in electrolysis should be followed up.

H. Char adsorption of water. The relative volatilities of isotope-differentiated compounds can be increased by adsorption on the active surface of a solid adsorbent. Table 6 compares the relative volatilities of water obtainable by char adsorption (*16*) and by distillation, under similar conditions.

Since staging a char adsorption plant would be expensive, a study design was set up for a single-stage vapor phase plant to provide feed enrichment for a more conventional separation plant. If the concentration of the feed to a conventional plant is doubled, the plant production can be approximately doubled. A small concentration effect obtained at a reasonable cost at the low concentration end is important in increasing the productivity of the whole plant.

The process was set up to adsorb at 86°F with 1.8 separation factor and desorb at 212°F with 1.2 separation factor. Ideal chromatographic type operation was assumed, with plug flow and complete attainment of equilibrium. A secondary plant operating at 20% recovery level was assumed available, and its backflow was routed through the char system to give a final waste water stream at two-thirds of feed water concentration. This resulted in a 33% recovery of feed deuterium by the char plant, with its product going to the secondary plant at 2.5 times feed concentration.

Taking the adsorption capacity at one lb. mole of water/1000 lbs. of char, and assuming two hours total adsorption-desorption cycle, the process inventory, at \$0.35/lb. for char plus tankage cost, becomes about \$95,000/ton/yr. D_2O capacity. Direct steam requirement charged at \$0.50/1000 lb. contributes an operating cost of about \$6.00/lb. of D_2O.

This would mean that \$250,000/ton/yr. secondary, or "main," plant with costs excluding depreciation of, say, \$15/lb. could produce 2.5 times as much D_2O, at \$100,000/ton/yr. onsite investment, and \$6/lb. To these would be added the char plant investment and operating costs, giving totals of \$195,000/ton/yr. and \$12/lb. before depreciation. A small but significant saving is shown. However, improvements over the case postulated would be required to assure the advantage and care for costs not allowed for in this incomplete evaluation.

From the eight processes described and compared with the standard H_2S/H_2O dual-temperature exchange process, it is evident that some cost reduction may be possible, but the savings are not likely to be large. Processes B, E, G, and H could be attractive if optimistic assumptions on critical features were to be confirmed by laboratory work.

Barr

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ACKNOWLEDGEMENT

The AEC's cooperation in arranging for publication of work performed under contract AT(30-1)-1407 is acknowledged with thanks.

BIBLIOGRAPHY

1. AEC Report NYO-6082, (SOA-95), Feb. 26, 1953, and summarizing letter NYO-6082 (SOA-94), Mar. 11, 1953.
   AEC Report NYO-6083 (SOA-103), June 1, 1953, and summarizing letter NYO-6083 (SOA-102), June 2, 1953.
   AEC Report NYO-6085 Rev., (SOA-165), Aug. 1, 1955, and summarizing letter NYO-6085 (SOA-171), Aug. 10, 1955.
   AEC Report NYO-7522, (SOA-186), Oct. 4, 1955, and summarizing letter NYO-7522 (SOA-185), Oct. 4, 1955.
   AEC Report NYO-7523, (SOA-188), Oct. 14, 1955, and summarizing letter NYO-7523 (SOA-187), Oct. 13, 1955.
2. AEC Report NYO-6084, "Bibliography on Deuterium Separation Methods," W. P. Drews, Dec. 4, 1953.
3. Murphy, G. M., H. C. Urey, I. Kirshenbaum, ed., "Production of Heavy Water," McGraw-Hill, New York, 1955.
4. Benedict, M., "Survey of Heavy-Water Production Processes," Proc. Int. Conf. Peaceful Uses of Atomic Energy, Geneva, 1955, *8*, 377 (Pub. 1956) P/819.
5. AEC Report NYO-6055, (SOA-60), "Review of the Ammonia/Hydrogen Dual Temperature System for Heavy Water Manufacture—Final Report," March 26, 1952, Std. Oil Dev. Co., Dev. Div., Esso Eng. Dept., and Proc. Div.
   NYO-6055 (Suppl. 1), (SOA-72), Mar. 28, 1952.
   NYO-6055 (Suppl. 2), (SOA-93), Feb. 19, 1953.
6. Barr, F. T., U. S. Pat. 2,676,873; Apr. 27, 1954 (filed June 16, 1942); "Catalytic Apparatus for Isotope Exchange." See also Ref. *3*.
7. Spevack, J. S., assignor to U.S. AEC. U. S. Pat. 2,787,526; Apr. 2, 1957 (filed Nov. 9, 1943); "Method of Isotope Separation."
8. Bebbington, W. P. and V. R. Thayer, "Production of Heavy Water," *Chem. Eng. Prog., 55*, 70 (1959).
9. Underwood, A. J. V., *Ind. Chemist, 10*, 128 (1934). Hunter, T. G., and A. W. Nash, *J. Soc. Chem. Ind, 51*, 285T (1932). See also Perry, "Chem. Eng. Handbook," p. 741, McGraw-Hill, New York, 3d ed., 1950.
10. Bigeleisen, J. and R. E. Weston, Jr., *J. Am. Chem. Soc., 76*, 3074 (1954). Weston R. E., Jr., and J. Bigeleisen, *J. Chem. Phys., 20*, 1400 (1952).
11. AEC Report NYO-889, "Low Temperature Heavy-Water Plant; Final Report," Mar. 15, 1951, (Hydrocarbon Research, Inc.).
12. AEC Report NBS-2626, "A Critical Review of the Literature Relating to the Vapor Pressure of Ammonia and Trideuter-ammonia," June 30, 1953, G. T. Armstrong.
13. National Research Laboratories (Ottawa) Report C50-495, "Possible Distillation or Similar Methods for the Recovery of D_2O," June 8, 1949, D. F. Stedman.
14. AEC Report ORNL-1448, "Chem. Tech. Quar. Prog. Rep.", Sec. 12, pp. 12, 13, Nov. 20, 1952.
15. MacLaren, J. A., Oak Ridge National Lab., Personal communication of Sept., 1953, discussing potentialities in the field of motor-electric potentials
16. Arii, *Bull. Inst. Phys. Chem. Res.* Tokyo, *16*, 749 (1937), as used by Stedman in Ref. *13*.

Figure 1. The tilting furnace apparatus used consisted of six furnaces mounted on a motor-driven tilting framework. The tilting cycling period used was measured in minutes.

Combating corrosion in molten extraction processes

Liquid metal reactor fuels pose severe corrosion problems. Results of corrosion-resistance tests on a wide range of commercial alloys and ceramic materials is given here.

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A proposed fuel for use in a Liquid Metal Fuel Reactor (LMFR) is a dilute solution of U, Mg, Zr, and fission products in Bi. By means of a process which has been under development at the Brookhaven National Laboratory (*1*), an important group of fission products may be continuously removed from the fuel by contacting it with a mixture of fused chlorides at 450 to 500°C. Although fused salts have been used industrially for many years, in pyrometallurgical refining processes, heat transfer, and metal heat treating applications, few corrosion data have been published, especially on fused chloride systems. One of the few existing pertinent papers (*4*) describes an extensive investigation of materials for molten chloride heat treating baths. This work (*4*) describes intergranular penetration along carbide networks as being far more important than the general solution of metal. High-nickel, low-chrome alloys were found to offer the most resistance to corrosion in 50-hr. tests at 870°C.

With little data available for interpretation, theories of fused chloride corrosion are largely speculative. Although substantial solubility of metals in their own salts has been noted (*5*), corrosion by salts of metals different from the container material is thought to occur generally as a result of electrochemical action rather than by physical solution. Effects commonly associated with physical solution, such as mass transfer corrosion, are nevertheless possible if, in the corrosion mechanism, a temperature dependent electrochemical equilibrium is involved.

It is apparent that the corrosion environment in a processing plant such as shown in Figure 2 would vary considerably from one point to another. Certain vessels and piping would be exposed to highly oxidizing $BiCl_3$ solutions while others would be exposed only to the relatively inert NaCl-KCl-$MgCl_2$ eutectic. Some components would be exposed to the molten fuel alone and others to the ternary salt alone. Contacting vessels would contain both fuel and salt in two-phase flow. Fission product decay heat might give rise to temperature gradients resulting in mass transfer corrosion.

No previous work seems to have been reported on corrosion by a two-phase liquid metal-fused salt system.

It was the purpose of the work described in this article to perform corrosion screening tests on materials of construction for an LMFR fuel processing plant. However, the testing program was not completed because of curtailment of work on fluid-fuel reactor concepts (*2*). But the principal results of the program obtained prior to the curtailment are reported here. Further details may be found in (*6*).

Corrosion by the liquid metal fuel, itself, was the subject of a separate program at Brookhaven (*3*), and hence no fuel corrosion tests *per se* were performed in the work described here. In the fuel corrosion program, most experience was obtained with a fuel composed of 1000 ppm U, 350 ppm Mg, and 250-350 ppm Zr in Bi. Mg was present as a getter to protect U from oxidation. Zr is believed to form a protective film of ZrN or ZrC on the container surface, by reaction with N or C from the container material. This fuel has been circulated for

Table 1. Nominal percentage composition of materials tested.

Metals and Alloys	Cr	Ni	Fe	Others
1020 mild steel	..	..	bal.	C-0.2
1¼ Cr-½ Mo steel	1.25	..	bal.	Mo-0.5
2¼ Cr-1 Mo steel	2.25	..	bal.	Mo-1
5 Cr steel	5	..	bal.	Mo-0.5
304 (ELC) S.S.	18	8	bal.	
310 S.S.	25	20	bal.	
316 S.S.	18	8	bal.	Mo-2-3
347 S.S.	18	8	bal.	Cb-10 × min. C content
410 S.S.	12	..	bal.	
430 S.S.	16	..	bal.	
16-1 Croloy	16.6	0.8	bal.	Mn-0.6
446 S.S.	25	..	bal.	
Inconel	15	bal.	7	
Inor-8	7	70.5	4.9	Mo-15.8
Hastelloy "C"	17	bal.	6	Mo-19
Tantalum	..	..	..	Ta-99.9
Molybdenum	..	..	..	Mo-99.9
Gold	..	..	..	Au-99.9+
Stellite 90	27	..	bal.	C-2.75: Mo, Ni, and Co-3

Ceramics	
Al_2O_3	Norton Mix A-402
MgO	Norton Mix M-202
ZrO_2	Norton Mix Z-301
SiC (nitride-bonded)	

many thousands of hours in thermal- and forced-convection loops made of low-chrome alloy steels (1¼ Cr-½ Mo and 2¼ Cr-1 Mo) with temperature differences of up to 100°C and at maximum temperatures of 550°C, without serious corrosion. Although the various aspects of the corrosion resistance of these steels have not yet been fully studied, at present one of the following would most likely be specified as the fuel container material for any proposed reactor experiment: 1¼ Cr-½ Mo, 2¼ Cr-1 Mo, or 1020 mild steel.

Experimental program

The corrosion screening program was designed to proceed from relatively simple and inexpensive small-scale static- and tilting-furnace capsule tests to tests in recirculating thermal- and forced-convection loops which more closely approximated the conditions of flow and temperature distribution which might arise in a processing plant. Materials which showed promise in capsule-scale tests and which at the same time were practical from the point of view of availability, high temperature strength, ease of fabrication, or compatibility with fuel were tested in recirculating loops. Capsule tests consisted of isothermal and nonisothermal exposures of materials of construction to corrodents for 1000 to 2500 hr. at 500°C. Loop tests were usually of longer duration.

A list of the materials tested is given in Table 1. Mill test reports are available (*6*). The metallic materials tested included mild steel, ferritic and austenitic stainless steels, high-nickel alloys, Ta, and Mo. This wide range was selected because of the general lack of corrosion information on which to base a narrower one. Haynes Stellite 90 was tested for potential service for valve seats. Mo, Ta, and the ceramic materials were of special interest as potential container materials for $BiCl_3$ solutions.

The following corrodents were used: the NaCl-KCl-$MgCl_2$ eutectic, the same eutectic with 5% $BiCl_3$, and each of these in the presence of the liquid metal fuel. The fuel and eutectic salt differed from what might be found in a processing plant principally in the absence of radiation and fission products. The effect of the presence of fission products was not explored before the corrosion study was terminated. No measurable radiation damage to the salt or enhanced corrosion of 347 S.S. was found in a single 1050-hr., 170,000 r/hr. static exposure in a Co-60 field (*6*).

The ternary eutectic salt was studied on all scales, in the static- and tilting-furnace capsules and in the thermal- and forced-convection loops. Solutions of 5% $BiCl_3$ in the eutectic were examined in static and tilting capsules. The two-phase liquid metal-fused salt system alone, or with 5% $BiCl_3$ in the eutectic, was studied only in the tilting furnace—a relatively simple apparatus in which two-

Table 2. Results of static screening tests of metals and alloys.

Test Duration — 1000 hr.
Test Temperature—500°C

Corrodent	NaCl-KCl-$MgCl_2$ eutectic			NaCl-KCl-$MgCl_2$ eutectic plus 5% $BiCl_3$		
Material	Type corrosion	Max. depth measured penetration, mils/yr.	Approx. weight change, %	Type corrosion	Approx. weight change, %	Residual % $BiCl_3$ in salt
1020 mild steel	none	0.7	−0.4	interg.	− 8	0.61
1¼ Cr-½ Mo steel		not tested		interg.	−20	0.30
5 Cr steel	pitting	17.5	not meas.		not tested	
2¼ Cr-1 Mo steel	interg.	< 1	−2.6	pitting	−14	0
347 S.S.	interg.	< 1	−0.6	interg.	−30	0
430 S.S.		not tested		interg.	−21	0.33
16-1 Croloy		not tested		interg.	−22	0.30
446 S.S.	interg.	< 1	−4.2	interg.	−27	0
Inor-8		not tested		interg.	−20	0.25
Stellite-90	interg.+ trans.	< 1	−0.2	interg.+ trans.	−17.5	0
Molybdenum	none	0	0		not tested	
Tantalum	none*	0	0		not tested	

Note: The results represent averages of 2-4 tests.
** Ta was embrittled.*

Table 3. Results of static screening tests of ceramics.

Test Duration — 1000 hr.
Test Temperature—500°C

Corrodent	NaCl-KCl-$MgCl_2$ eutectic		NaCl-KCl-$MgCl_2$ eutectic plus 5% $BiCl_3$		
Material	Condition specimen after test	Approx. weight change, %	Condition specimen after test	Approx. weight change, %	Residual % $BiCl_3$ in salt
Al_2O_3 (Norton Mix A-402)	no spalling or cracking	−0.14	no spalling or cracking	+0.2	4.5
MgO (Norton Mix M-202	all specimens cracked and spalled	+4	all specimens cracked and spalled	+6	2.1
ZrO_2 (Norton Mix Z-301)	moderately spalled	−1.0	slight attack	+0	4.4
SiC (nitride-bonded)	all specimens crumbled completely	—	all specimens crumbled completely	—	3.5

Note: Results are averages of 2-4 tests.

phase, nonisothermal flow may be obtained.

Certain experimental procedures such as material preparation and corrodent analysis were, for the most part, common to all tests.

Preparation of materials. It was essential that all purification and handling of purified corrodents in the liquid state be performed in an inert atmosphere since both the liquid metal fuel and fused salts were subject to rapid attack by atmospheric oxygen and moisture. Inert atmospheres were essential in the tests themselves for the same reason. In addition, corrosion by fused salts would have been greatly enhanced by the presence of oxidizing impurities. Consequently, all apparatus in which the corrodents were prepared or in which the tests were conducted was thoroughly cleaned, and tested for leak-tightness (with a He mass spectrometer detector) before use. Inert atmospheres of either He or A were used. They were purified by passage over Ti chips at 850°C.

Fuel which had been exposed to atmospheric air in the solid state was slowly heated and melted under vacuum before use. Purified solid salts were handled in a dry box as much as possible. Periods of handling in air outside the dry box were no longer than a few seconds, and were immediately followed by evacuation and purging with He.

The eutectic was prepared by vacuum-melting the constituent salts in the proper proportions, and outgassing at 500°C to a pressure of less than 20μ. Reagent-grade NaCl, KCl, $BiCl_3$, and anhydrous $MgCl_2$ were used. Small batches of salt for the static tests were prepared in Pyrex, while 100-lb. batches of salt were prepared in a 347 stainless steel tank for use in the other experiments. Prior to use, the 100-lb. batches of salt were contacted with Bi, containing 0.5% Mg, 0.1% U, and 0.025% Zr to reduce any oxides present to the Bi phase. The $BiCl_3$ was purified by vacuum sublimation at 225°C. Before use, the salts were filtered through fine Pyrex or stainless steel frits.

The 99.999% pure Bi, spectrographically pure Mg, and reactor-grade Zr were degreased with acetone, and natural U was nitric-acid cleaned to remove surface oxides, and degreased with acetone prior to use. The Bi fuel, containing 1000 ppm U, 350 ppm Mg, and 350 ppm Zr was prepared by dissolving weighed quantities of these additives in the Bi at 500°C, accompanied by light vibration of the container.

Flat metal tab specimens were used in the static- and tilting-furnace experiments. One face was polished and the other sandblasted to simulate possible surface cleaning treatments used in fabrication. Each specimen was weighed before testing. The loop-test specimens were polished lengths of pipe welded directly into the flow circuit. A short section of each such specimen was set aside for reference. Specimens for the tilting-furnace and loop tests were prepared from the same stock as that used in fabrication of the container. Ceramic tabs were dried to constant weight at 200°C before use.

Examination and analysis. On com-

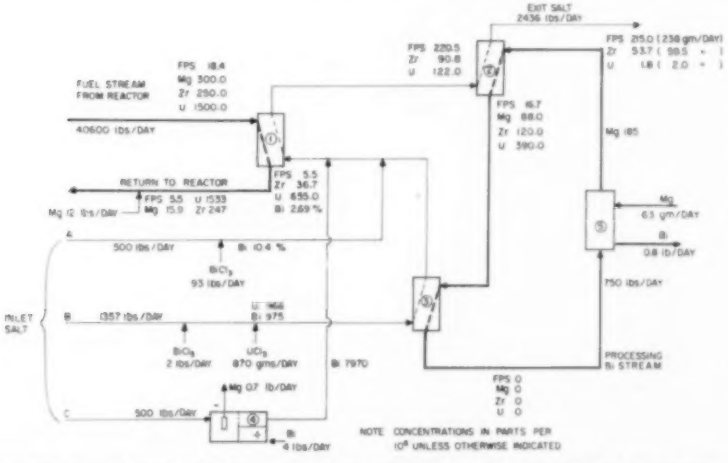

Figure 2. A small portion of the fuel stream is continuously fed to extraction column No. 1, in which it is contacted with the fused eutectic mixture of NaCl, KCl, and $MgCl_2$ (30, 20, and 50 mole percent, respectively; m.p. 396°C). A small amount of strong oxidant, $BiCl_3$, is added to the influent salt. Those fission products (identified as FPS) whose chlorides are more stable than $MgCl_2$, and some U are oxidized into the salt in this column. Makeup Mg is added to the fuel before it is returned to the reactor. U in the salt leaving Column 1 is recovered by reduction into a solution of Mg in Bi in Column 2. It is then oxidized into the incoming salt by $BiCl_3$ in Column 3.

pletion of the tests, each tilting-furnace capsule and thermal-convection loop was radiographed to determine the location and extent of gross corrosion and deposition. Then, for all tests, test specimens were recovered and washed with distilled water to remove all traces of adhering salt. Ceramic specimens were refluxed with distilled water and dried to constant weight at 200°C. Adhering Bi was removed from tab surfaces by dissolution in Hg at 200°C and all capsule specimens were then weighed. Metallic specimens were examined metallographically to determine the type and extent of corrosion. Maximum depth of specimen penetration was measured on photomicrographs. Ceramic specimens were examined visually. Whenever possible, the corrodent solution and any plug material were analyzed chemically.

Capsule-scale experiments involved two to four replicate capsules for a given material. Although there was a considerable amount of scatter within groups of measured weight changes and depths of penetration for a given material, cases of substantial corrosion were clearly evident.

In the following sections, the tests will be described and the results given according to apparatus type, proceeding in the order of increasing scale.

Static capsule tests

Twelve metallic and four ceramic materials were exposed to the eutectic and to a solution of 5% $BiCl_3$ in the eutectic in static corrosion tests. Fifteen-gram batches of salt were weighed out in a dry box and placed in Pyrex capsules with ⅝ in. × ⅝ in. × 0.030 in. test specimens. The capsules were sealed under vacuum and placed in a furnace maintained at 500°C. The tests were performed in quadruplicate for 1000 hr.

The results of the tests are presented in Tables 2 and 3. 5 Cr steel pitted and Ta suffered embrittlement. None of the other metals, including Haynes Stellite 90, was seriously attacked by the eutectic. On the other hand, with the $BiCl_3$ solution, all of the metallic specimens were severely corroded intergranularly and, in some cases, transgranularly, as well. The 2¼ Cr–1 Mo steel was pitted. All cases of attack were accompanied by significant weight losses and almost complete reduction of the $BiCl_3$. The original surfaces of the metallic specimens were completely dissolved.

Al_2O_3 was the only ceramic tested which was not attacked by either the eutectic or a solution of $BiCl_3$ in the eutectic. In both cases, MgO and ZrO_2 cracked and spalled to some extent, while the nitride-bonded SiC crumbled completely. Although there was some loss of $BiCl_3$, particularly with MgO, no metallic Bi was found.

Tilting furnace capsule tests

The tilting furnace apparatus is a relatively simple apparatus for initial screening tests of materials for resistance to mass transfer corrosion. Because of its simplicity and the fact that both one- and two-phase corrodents could be accommodated, it was widely used in the present investigation.

The apparatus consisted of six furnaces mounted on a motor-driven tilting angle-iron framework, Figure 1. The furnaces were made from Mullite tubes (18 in. long by 1¾ in. I.D.) wound with Kanthal A resistance heater wire. One end of the tubes was left unwound to promote axial temperature gradients in capsules placed in the furnaces. Flow of corrodents within the capsules was obtained by slowly tilting the furnaces back and forth. The tilting cycle was 125 sec. with 37-sec. delays at each extreme position to allow the corrodent temperatures to equilibrate. The axial position of the capsules within the furnaces was adjusted so that the hot ends were maintained at 500°C and the cold ends at 450°C.

Figure 3. Partially assembled thermal convection loop. A surge tank is mounted at the top of the piping. The entire loop is wrapped with heater wire and insulated.

Tests were carried out in duplicate for 1000 or 2500 hr. in capsules made from fully-annealed tubing or pipe. Test tabs were formed from the same stock and mounted in the hot end of the capsules. A group of two or four capsules was bundled together with two thermocouples and tested in a single furnace. Both thermocouple measuring junctions were located on the axis of the capsule bundle in contact with each capsule. One thermocouple measured the temperature at the hotter ends and the other at the colder ends of the capsules.

With the particular capsule and furnace design used, it was found that the maximum temperature existed near the middle of the capsule rather than at the hot end where the test tab was located. Therefore, corrosion product content of corrodent and corrosion product deposition could not be principally associated with attack on test tabs. In spite of this limitation, the design was thought to be adequate for screening purposes. All corrodent combinations were used in the tilting-furnace tests.

Capsules were prepared from 12.5-in. lengths of pipe or tubing of the metal being tested which had been internally sandblasted. A test tab was securely positioned in one end of each capsule. The ends of the capsules were crimped by a hydraulic ram and seal-welded.

In the single-phase experiments each capsule contained just sufficient salt to completely immerse the test tab in the lowest position in the tilting cycle. In the two-phase experiments the test tab was again just fully immersed in the lowest position with the Bi-salt interface at the center of the tab.

Most capsules were prepared in this manner. Special designs were required for capsules made of Ta, Mo, and Au (*6*).

The results follow:

NaCl-KCl-$MgCl_2$ Eutectic Tests—Type 310 stainless steel, 1020 mild steel, and Mo were not attacked after 1000-hr. exposure to eutectic salt, Table 4. No corrosion was found in a 2500-hr. test of 2¼ Cr-1 Mo steel (not shown in Table 4). Slight intergranular corrosion of most of the other materials was found. Type 347 stainless steel and 2¼ Cr-1 Mo steel

Table 4. Results of tilting-furnace screening tests without $BiCl_3$.

Test temperature difference — 50°C (500°—450°C)

Test duration—1000 hr.

Corrodent	NaCl-KCl-$MgCl_2$ eutectic			Bi-U fuel/eutectic		
Material	Type corrosion polished side of tab	Max. penetration, mils/yr.	Weight change of tab mg/(sq. cm.)(yr.)	Type corrosion polished side of tab	Max. penetration, mils/yr.	Weight change of tab, mg/(sq. cm.)(yr.)
1020 mild steel	none	0	−22	none	0	+ 3.3
2¼ Cr-1 Mo steel	interg.+ trans.	3	+12.2	none	0	+ 3.8
304 (ELC) S.S.	interg.	< 0.4	−12.1	interg. + trans.	15	− 9.8
310 S.S.	none	0	− 2.8	interg. + trans.	6.4	− 102
316 S. S.	interg.	< 0.4	− 2.9	interg.	6.0	− 7.1
347 S.S.	interg.+ trans.	4.7	− 4.6	interg.	10	− 7.2
410 S.S.	interg.	1.0	− 4.1	interg.	6	− 57
430 S.S.	trans.	2	− 0.8	interg.	5.2	not meas.
16-1 Croloy	interg.	< 0.4	+10.7	interg.	4.4	− 40
446 S.S.	interg.	< 0.4	+ 4.2	none	0	− 3
Inconel	interg.	1.8	− 3.2	interg. + trans.	too extensive to measure	− 525
Hastelloy "C"	not tested			interg. + trans.	32	− 162
Inor-8	trans.	2	not meas.	interg. + trans.	too extensive to measure	−1000
Molybdenum	none	0	− 2.8	none	0	+ 0.4
Tantalum	interg.	2.9	− 1.0	trans.	4.1	− 8.3

Note: Results are averages of 2 tests.

were attacked transgranularly also. Inor-8 and Type 430 stainless steel showed only slight transgranular attack. Traces of magnetic deposition were present in the cold ends of several capsules, but there was not enough material to analyze.

Similar results, not shown in Table 4, were obtained when weld specimens of 2¼ Cr-1 Mo steel, Types 347 and 446 stainless steel, and Inconel were tested for 2500 hr. In each case, the welds were stress-relieved before testing. Negligible corrosion was observed at each weld.

The results of the chemical analyses of the corrodents from the steel and Ni alloy capsules showed that Cr was present in the largest concentration (75 to >1000 ppm), followed by Fe (20-190 ppm), and Mn (20-320 ppm). Very little Ni (up to a maximum of 40 ppm) was found. Up to 100 ppm Ta and 600 ppm Mo were found in their respective tests.

Bi-U Fuel/Eutectic Tests—Mo, 1020 mild steel, 2¼ Cr-1 Mo steel, and Type 446 stainless steel were not attacked after 1000-hr. exposures to Bi-U/salt, Table 4. No corrosion was found after a 2500-hr. test of 2¼ Cr-1 Mo steel. Corrosion of the other materials was primarily intergranular. In most cases, corrosion was also accompanied by metallic deposition at the cold end. Generally, the greater the tab weight losses, the greater was the amount of this deposition. The capsule and tab surfaces were generally found to be wetted by the Bi. In addition, no salt was found to be present at the Bi-capsule wall interface, indicating that the salt may not creep into the Bi fuel system in a processing plant.

The corrosion which occurred in the tilting-furnace tests with Bi-U/salt corrodents was similar in type and extent to that caused by Bi-U fuel in the absence of salt. Alloys containing Ni were severely attacked to the accompaniment of significant weight losses and extensive mass transfer. Ni is soluble in Bi, and the corrosion generally was by intergranular attack. In the cases of Types 304 (ELC) and 310 stainless steels and the high Ni alloys (Inconel, Inor-8, and Hastelloy "C"), this dissolution was so great that extensive transgranular attack also occurred.

Ta was transgranularly attacked. Previous tests at Ames Laboratory (7) with Bi alone did not produce any significant attack at 1000°C.

Type 446 was the only 400 series stainless steel that was not attacked. The corrosion resistances of Type 430 stainless steel and 16-1 Croloy (similar to Type 431 (ELC) stainless steel) were similar. Type 410 stainless steel was the least resistant in this series.

Fe and Ni were the principal corrosion products found upon analysis of the corrodents from steel and Ni alloy capsules. The Ni concentrated principally in the Bi phase (up to 1.65%), while Fe was found primarily in the salt (up to 575 ppm). No Mo was found in the Bi and less than 100 ppm in the salt, while 30 ppm Ta was found in the Bi and 45 ppm in the salt.

Eutectic/$BiCl_3$ and Bi-U Fuel/Eutectic/$BiCl_3$ Tests—Mo and Ta were tested with a 4.76% solution of $BiCl_3$ in eutectic alone and in the presence of Bi-U fuel, Table 5. Au was tested with a 4.76% solution of $BiCl_3$ in eutectic alone, Table 5. Because of experimental difficulties, not all the tests were of the same duration. The Mo and Ta were slightly pitted or corroded transgranularly, although the $BiCl_3$ was almost completely reduced. Only Au did not corrode significantly or reduce $BiCl_3$ during these tests.

Thermal convection loop tests

Mass transfer corrosion tests were performed in three thermal convection loops, one each of 347 stainless steel, 410 stainless steel, and 2¼ Cr-1 Mo steel. In addition to being larger in scale than tilting-furnace capsules, these loops have the advantage that

Table 5. Results of tilting-furnace screening tests with $BiCl_3$.

Test temperature difference—50°C (500°—450°C)

Corrodent	—NaCl-KCl-$MgCl_2$ eutectic plus 4.76% $BiCl_3$—					—Bi-U fuel/eutectic plus 4.76% $BiCl_3$—				
Material	Length test, hr.	Type corrosion polished side of tab	Max. penetration, mils/yr.	Weight change of tab, mg/(sq.cm.)(yr.)	Residual $BiCl_3$ content of salt, %	Length test, hr.	Type corrosion polished side of tab	Max. penetration, mils/yr.	Weight change of tab, mg/(sq. cm.)(yr.)	Residual $BiCl_3$ content of salt, %
Molybdenum	600	pitting	2.2	not meas.	< 0.05	2500	trans.	1.8	−1.1	0.24
Tantalum	1600	pitting	1.4	−45	< 0.05	2500	trans.	1.8	−7.9	0.15
Gold	1000	interg.	1.0	−1.1	4.92		not tested			

Note: Results are averages of 2 tests.

they may be sampled during the course of an experiment. Salt velocities comparable to those expected in a processing plant (0.2-0.3 ft./sec.) may be obtained.

The loops, Figure 3, were fabricated from 3-ft. lengths of ½-in. IPS pipe. A 4-in. IPS surge tank was located at the top of the piping, immediately above a test specimen. Charging and sampling connections were mounted at the top of the surge tank. The entire loop was wrapped with heater wire and insulated. Different heater circuits were used on the hot and cold sections of the loop, so that a controlled temperature difference could be maintained.

Each loop was degassed to a pressure below 1μ at 550°C. It was then charged by inserting a salt-filled glass tube, open at the bottom, through airlocks into the heated surge tank, where the salt was melted.

The loops were sampled weekly with graphite cups by the thief sampling method (8). Radiographs were also taken weekly to observe the extent of corrosion and deposition. The salt temperature was measured with a flexible thermocouple probe inserted through the sampling port into the loop piping. The temperature difference between the hot and cold legs was determined from the maximum and minimum temperatures obtained during a traverse of the loop.

The results of these tests are shown in Table 6. The eutectic was circulated in the 347 S.S. loop at a calculated velocity of 0.25 ft./sec. for 2467 hr. with a maximum salt temperature of 500°C, and a measured temperature difference of 45°C. The loop was shut down when a sample cup was accidentally dropped in it and salt flow was restricted. Slight intergranular corrosion (3.9 mils/yr. maximum penetration) was found in the hot leg; none was found on the polished test specimen. A small deposit of an Fe-Cr-2% Ni alloy was found in the cold leg. Fe, Cr, and Mn reached concentrations in the salt of 300, 375, and 25 ppm, respectively. No Ni was detected.

The same eutectic salt mixture was circulated in the 410 S.S. loop at 0.17 ft./sec. (calculated) for 3971 hr. at a maximum salt temperature of 494°C, and a measured temperature difference of 42°C. The test was terminated because of plugging of the cold leg. Slight transgranular corrosion (3.3 mils/yr. maximum penetration) was found in a small area of the hot leg. An Fe-10% Cr alloy was deposited in the cold leg. Fe, Cr, and Mn concentrations in the salt reached 700, 1000, and 80 ppm, respectively. No Ni was detected.

The eutectic was also circulated in the 2¼ Cr-1 Mo steel loop at 0.26 ft./sec. (calculated) for 6281 hr. at a maximum salt temperature of 501°C, and a measured temperature difference of 49°C. The loop was shut down voluntarily. Slight transgranular and intergranular attack was found throughout the entire loop, averaging 2.1 mils/yr. with 3.1 mils/yr. maximum penetration. Attack on the polished test specimen was 1.1 mils/yr. average, and 1.4 mils/yr. maximum. An Fe-2% Cr alloy deposit was found in various parts of the loop. The Fe, Cr, and Mn concentrations in the salt reached 1750, 580, and 140 ppm, respectively.

The corrosion in these loop tests was low, and welds were not preferentially attacked. The highly-polished test specimen surfaces in the loops corroded appreciably less than the corresponding pipe surfaces which had been sandblasted prior to assembly. The compositions of the deposits were similar to those of the original steel.

Forced circulation loop test

Some information on corrosion by the ternary eutectic was obtained from the operation of a mechanical components test loop, Figure 4, made of Type 347 stainless steel. The loop was operated isothermally at velocities of 2 to 13 ft./sec. In the first of two tests (see Table 6), which were primarily pump tests, the salt was circulated for 1034 hr. at 520°C and a maximum velocity of 13.2 ft./sec. Upon conclusion of the test, a ½-in. IPS polished test specimen was removed from the loop and examined metallographically. Slight transgranular attack (1.3 mils/yr. maximum penetration) was found.

The loop was sampled periodically during the first run, and the salt was analyzed for corrosion products. The Ni concentration remained constant at 10 ppm for the entire test, while the Mn concentration increased slightly from 10 to 21 ppm. The Cr concentration increased rapidly from 23 to 90 ppm in the first 80 hr., and then more slowly to 155 ppm, and Fe increased from 10 to 800 ppm.

In the second test the salt was circulated for 656 hr. at 515°C, at velocities varying from 1.8 to 7.9 ft./sec. A section of ½-in. IPS pipe, whose surface had been sandblasted during fabrication, was removed and examined. Transgranular attack (10.7 mils/yr. maximum penetration) was found. As in the case of the thermal convection loops, the corrosion of highly polished metal surfaces in this loop was appreciably less than for a sandblasted one.

Discussion

The NaCl-KCl-$MgCl_2$ eutectic was tested by itself in all apparatus types with a wide variety of metallic materials and some ceramics. With few exceptions, it produced little corrosion. Weld areas were not preferentially attacked. The extent of mass transfer attack by the eutectic was negligible in 1000-hr. tilting-furnace capsules, but plugging did occur in the 410 stainless steel thermal convection loop after 4000 hr. of operation. It may be significant that little or no Ni was found in corrodent analyses in any of the tests of Ni-bearing alloys. Thus this fact suggests that further studies might show high Ni alloys to be superior to all others tested here.

The tests do not clearly show a

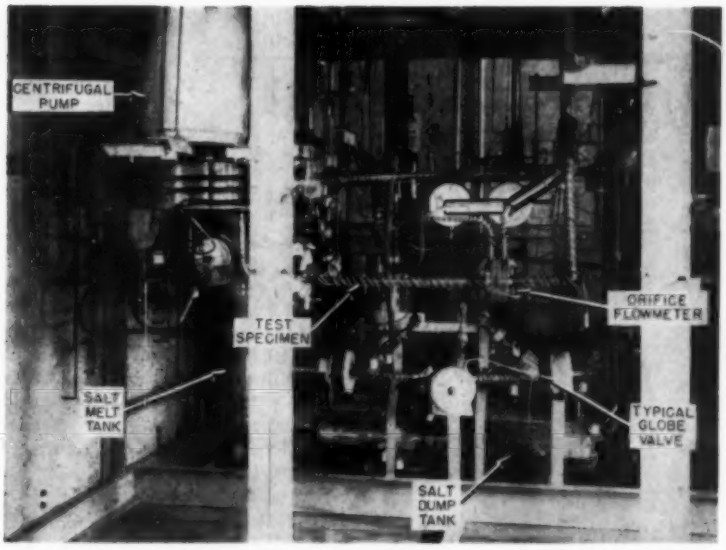

Figure 4. View of forced-circulation loop for fused salt prior to application of insulation.

superior container material or particular range of superior container material compositions for the ternary eutectic. Hence a wide variety of materials is available for further study and experimental use. The fact that the ternary eutectic produced little corrosion, plus the observation that on completion of the tests there was generally no evidence of discoloration due to rust within test apparatus, indicates that the methods of corrodent purification and handling were effective and that the different types of apparatus were leaktight.

Corrosion by the liquid metal-fused salt system in the absence of $BiCl_3$ resembled that expected in the presence of fuel alone. Alloys which are resistant to fuel were found to be resistant to fuel in the presence of salt. The selection of a container material for the two-phase system thus appears to hinge on the selection of a container material for fuel. Mild steel, 1¼ Cr-½ Mo, or 2¼ Cr-1 Mo are most likely for this purpose at present.

The fact that, on completion of the experiments, the container surfaces were found to be wetted by the Bi and salt was never found at the Bi-container interface, suggests that creep of salt into the fuel system via such interfaces may not occur in a processing plant.

In the presence of liquid-metal fuel and 5% $BiCl_3$ in ternary eutectic, both materials tested, Mo and Ta, were subject to transgranular attack and the $BiCl_3$ was almost completely reduced. However, in these tests $BiCl_3$ was present chemically in excess of the oxidizable fuel solutes, U, Mg, and Zr. When U, Mg, and Zr are present chemically in excess of $BiCl_3$, it has been found in other work at Brookhaven (9) that the fuel solutes are oxidized and not the container material. This has been found to be true in repeated experiments involving 347 stainless steel and Mo containers. Thus it appears that contacting vessels in a processing plant in which $BiCl_3$ will be present, may be made of materials selected primarily for resistance to fuel, as long as $BiCl_3$ is not in excess of oxidizable fuel solutes. Such is the case in the process flow sheet, Figure 2.

The principal corrosion problem in the process appears to be that of containing solutions of $BiCl_3$ in eutectic, from the point of makeup to the point of consumption. Although Al_2O_3 and Au withstood attack by this corrodent in capsule experiments, further experiments, on a larger scale, would be required before they could be recommended as practical materials of construction.

In all tests, mechanically polished surfaces generally withstood attack better than sandblasted surfaces.

Table 6. Thermal and forced-convection loop corrosion test results.

Corrodent	NaCl-KCl-$MgCl_2$ eutectic				
	—Thermal Convection Loops—			Forced Circulation Loop	
Material	347 S.S.	410 S.S.	2¼ Cr-1 Mo	347 S.S.	
Operating time, hr.	2467	3971	6281	1034	656
Max. salt temp., °C	500	494	501	520	515
Salt ΔT, °C	45	42	49	isothermal	
Velocity, ft./sec.	0.25	0.17	0.26	13.2	1.8-7.9
Types of corrosion	interg.	trans.	trans. and interg.	trans.	trans.
Max. attack, mils/yr.	3.9	3.3	3.1	1.3[a]	10.7
Composition of deposited material	Fe-Cr, 2% Ni	Fe-10% Cr[b]	Fe-2% Cr		

[a] *Pipe specimen surface was mechanically polished prior to the test. All others in the in the table were sandblasted.*

[b] *Loop plugged.*

ACKNOWLEDGMENT

The authors gratefully acknowledge the contributions of the following Brookhaven National Laboratory staff members and groups: Messrs. G. Farber and W. Hansen in the development of experimental techniques and for conducting experiments; Messrs. O. E. Dwyer and J. R. Weeks for their helpful suggestions and advice; the Metallography Section for examining the corrosion specimens; and the Hot Laboratory Radiochemical Analysis Section for analyzing the corrodents. The ceramic and Inor-8 test materials were supplied by the Norton Company and Oak Ridge National Laboratory, respectively.

This work was done under contract with the AEC.

LITERATURE CITED

1. Dwyer, O. E., A. M. Eshaya, and F. B. Hill, "Continuous Removal of Fission Products from U-Bi Reactor Fuels," Proc. 2nd Int. Conf., *17*, 428-37, U. N., Geneva, 1958.
2. Report of Fluid Fuel Reactors Task Force to Div. of Reactor Dev. USAEC, TID-8507, Feb. 1959.
3. Klamut, C. J., D. G. Schweitzer, J. G. Y. Chow, R. A. Meyer, O. F. Kammerer, J. R. Weeks, and D. H. Gurinsky, "Material and Fuel Technology for an LMFR," Proc. 2nd Int. Conf., *7*, 173-195, U. N., Geneva, 1958.
4. Jackson, J. H., and M. H. LaChance, "Resistance of Cast Fe-Ni-Cr Alloys to Corrosion in Molten Neutral Heat Treating Salts," *Trans. Am. Soc. Metals*, *46*, 157-183, 1954.
5. Bredig, M. A., J. W. Johnson, and W. T. Smith, Jr., "Miscibility of Liquid Metals with Salts, I. The Sodium-Sodium Halide Systems," *J. A. C. S.*, *77*, 307-12, Jan. 20, 1955.
6. Susskind, H., F. B. Hill, L. Green, S. Kalish, L. Kukacka, W. E. McNulty, and E. Wirsing, "Corrosion Studies for a Liquid Metal-Fused Salt Extraction Process," BNL-585 (To be Published).
7. Fisher, R. W., and G. R. Winders, "High Temperature Loop for Circulating Molten Metals," *A.I.Ch.E. Ann. Mtg.*, Paper No. 26, Nov. 29, 1955.
8. Raseman, C. J., and J. Weisman, "Liquid Metal Fuel Reactor Processing Loops, Part I," BNL-322, June 1954.
9. Salsano, F. J., and F. B. Hill, Unpublished BNL.

C. F. Paulson

Performance of magnetite bed filters

Radioactivity and insoluble corrosion products can be effectively removed from a pressurized-water reactor coolant by use of magnetite bed filters. Here are the test results.

All pressurized-water reactor plants built to date have incorporated a continuous bypass purification system. The purification system serves to:

1. control concentration of dissolved and suspended solids, which may be radioactive or subject to activation by neutron flux, to limit radioactivity levels in the primary water and in the reactor compartment.
2. remove suspended or dissolved matter which may deposit on heat transfer surfaces and reduce heat transfer rate.
3. remove suspended matter which might interfere with satisfactory operation of valves, pumps, and mechanisms.

To remove electrolytes and control pH, an ion exchanger has been used. Satisfactory ion exchange systems have been developed and are now in operation. Ion exchangers also act as filters but are not ideal for this purpose.

The problems associated with purification were greatly accentuated when carbon steel was chosen as the chief material of construction of a pressurized-water reactor. The corrosion rate of carbon steel is substantially higher than that of stainless steel, making the potential load of corrosion products higher. When the theoretical rate of insoluble corrosion products (crud) released from the carbon steel plant was calculated and predictions were made of the initial and steady-state crud concentrations at various purification flow rates, the calculated crud concentrations were found to be higher than had been experienced in previous plants. It was necessary to develop a satisfactory filter to limit crud levels to acceptable values. The sintered metal filter used in early plants was found unsatisfactory.

Reported here are the results of the program to develop and test an axial flow magnetite bed filter to operate at system temperature.

The experimental facilities used for these tests include a closed piping loop operating at high temperature (500°F) and pressure (2000 lb./sq. in.). A canned motor pump circulates water continuously through the piping loop at velocities in the range of 15 to 30 ft./sec. Corrosion occurs upon the pipe wall and some of the corrosion products enter the circulating water stream as insoluble suspended material. A side stream is removed from the high-pressure side of the pump, passed through the bypass purification system, and returned to the suction side of the pump.

The various loop facilities used in portions of this test were as follows:

Loop 1. A large, pump test loop fabricated of carbon steel.

Loop 2. A pump test loop fabricated of carbon steel, with more carbon steel surface added in the form of a bundle of carbon steel tubes.

Loop 3. A pump test loop fabricated of stainless steel, with carbon steel surface added in the form of a bundle of carbon steel tubes.

System A. Pressurized-water reactor plant. The wetted surface was about two-thirds stainless steel and one-third carbon steel. During the test period this plant was generating power.

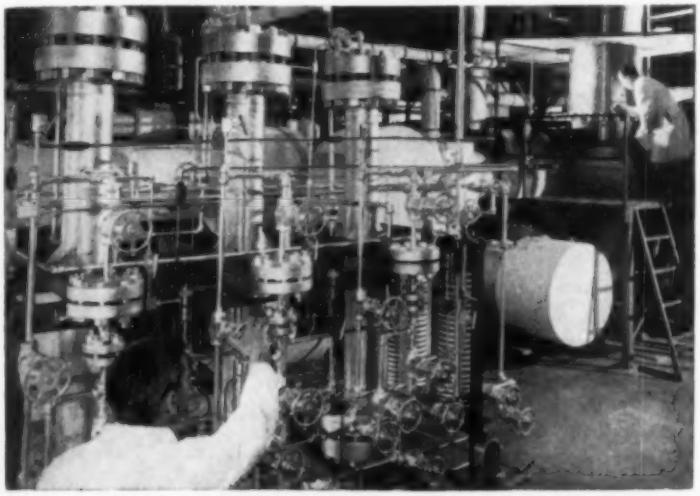

Figure 1. Filter test panel. In the foreground is the experimental set up used on Loops 1 and 2. Loop 1 is in the background.

System B. A pressurized-water reactor fabricated chiefly of carbon steel.

The tests carried out in the first four loops were intended to provide the design basis for System B. The tests on System A filter were made to confirm the design. Because of the need for simultaneous testing and design work, not all of the test results could be incorporated into the design.

Two grades of magnetite were used in the tests. Most of the tests were conducted on Permanite 40-70 mesh supplied by the Foote Mineral Company. Some tests were also conducted upon an experimental grade of magnetite produced by Jones and Laughlin Steel Corporation which had preferable particle shape and uniformity coefficient, and less leachable materials. However, its manufacture was discontinued at about the time these tests were completed.

Performance data

The crud removal data on the hot axial flow filter were obtained chiefly in the Loop 1 and 2 tests. The method used involved a sintered metal filter downstream of the magnetite filter to collect anything which passed through the magnetite. The inlet crud concentration was established by sampling and by a cold filter and ion exchanger, each in parallel with the hot filter. Accumulations of crud on the sintered metal filter were negligible, and rate of pressure drop buildup across it was very small, indicating that the magnetite filter removed anything which could be held on a sintered metal filter.

Table 1. Hot axial flow magnetite filter performance.

Loop	1	1 and 2	2	2	2	3	System A	System A[a]	System B
Service time, hr.	300	294	326	321	304	1350	700	600	1500
Flow loading, lb./(min.)(sq. ft.)	130	65	235	64	96	33	175	175[b]	40-83
Bed depth, in.	30	30	30	30	30	30	18[c]	18[c]	24
Bed diameter, in.	5	5	5	5	5	5	6.8	6.8	40.5
Crud removal efficiency	high	high	high	high	high	62.4	0	0	66%
Initial pressure drop, ft. H_2O	6.7	10.0	14	4	5	2.3	10	11.5	..
Final pressure drop, ft.. H_2O	8.2	6.5	15.5	7	12	2.0	12.6	11.5	..
pH	7.0	7.0	7.0	10.0	10.0	7.5-9.0	9.7	9.2	9.5-10.5
Area crud loading, g./sq. ft.	706	390	420	1400	1140	151	..	..	..

[a] *Continuation of run summarized in previous column. Only change was from LiOH ion exchange resin to NH_4OH.*

[b] *This flow loading was 258 lb./(min.)(sq. ft.) for three days and no performance differences were noted..*

[c] *The initial bed depth was 18 in. The final bed depth was 13 in.*

Table 2 shows the distribution of crud in the various quarters of the magnetite bed used on Loops 1 and 2. About half of the crud was found in the top 25% of the bed. From this it appears that a crud loading based upon the cross-sectional area of the filter is of the greatest significance in comparing various tests.

The over-all amount of crud removal in the Loop 3 filter was 62% of the influent. During much of the time, the influent crud was below 0.05 ppm and there was no decrease in crud concentration on passage through the bed. Similarly, the crud concentration in System A was low, and there was a net increase in crud concentration on passage through the bed. The filter in System A did, however, remove more than 80% of the activity from the influent crud.

These considerations lead to the conclusion that the filter effectively removes most of the crud as it enters. However, a rather constant release of material took place equivalent to about 0.02-0.05 ppm crud. The material could have been crud which was previously filtered and then slowly percolated through the bed to a point where it could be released back to effluent water. Alternatively, the material could have been attrition products or leached products from the magnetite. The second supposition was supported by observations on the System A filter at startup, when the effluent crud was brownish and slimy as compared to the black particulate inlet crud. The second observation was also supported by the decrease in activity of the crud. However, since the effluent crud had some activity, there must have been some leakage of the influent crud as well. The half life of the crud was too long to permit

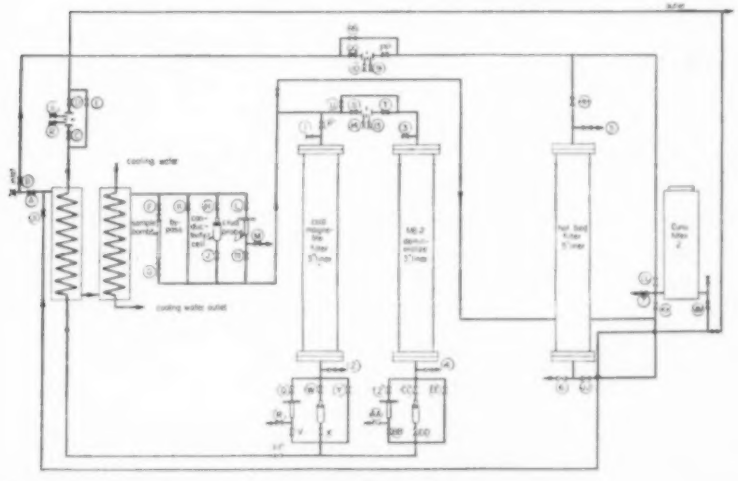

Figure 2. Flow diagram of test panel shown in Figure 1.

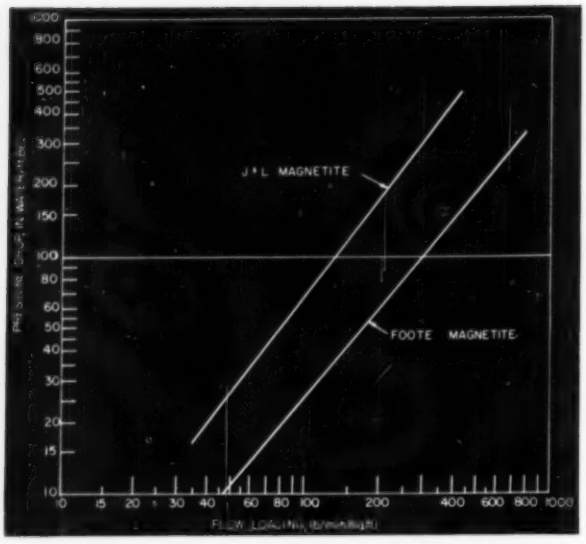

Figure 3. Hot axial flow magnetite pressure drop vs. flow.

decay to cause any appreciable decrease in activity on passage through the filter bed.

Table 3 summarizes the performance of the filter in System A during its last period of operation. It is evident that in most cases there was an increase in crud concentration during passage through the bed and that in most cases the crud specific activity was lowered. The product of these two terms (here called the activity concentration product) represents the activity contribution of the insoluble corrosion products to the water specific activity. It also is a good measure of the activity removal efficiency of the filter. The crud removal efficiency was based upon the change in the activity concentration product. With the exception of the first period of measurement, the crud removal efficiency was high. The first period coincided with other changes in plant water chemistry and therefore may not be representative of normal operation.

The water specific activity is measured by drawing a water sample, without external filtration, and evaporating this to dryness. It is counted 15 minutes after withdrawal and thus represents chiefly short-lived activity, plus a contribution from the long-lived insoluble corrosion product activity. The insoluble corrosion product activity contribution, represented by the activity concentration product, can be subtracted from the gross water specific activity to obtain the soluble activity. The difference between inlet and outlet soluble water specific activity has been listed as a percentage in Table 3. It varies from −9.2 to 29.6%, with an average of about 18%. Unfortunately the nuclides contributing to the soluble water specific activity difference were not identified. However Mn-56 is known to be a major contributor to the water specific activity, and it is assumed that much of the reduction in activity resulted from Mn-56 removal. Reference (*1*) indicated that a filter of comparable design removed some soluble fission products and also some soluble long-lived corrosion product activity.

Results

The last column of Table 1 summarizes the performance data on the System B filter, before the reactor first generated nuclear power. It can be seen in Figure 4 that contrary to pilot plant experience at such low crud concentrations, the crud concentration was always lowered by passage through the filter. During the first 700 hours, the filter operated at temperatures below 300°F and effectively purified the reactor coolant. Starting at 700 hours, the coolant was hot, and the filter was even more effective.

It must be borne in mind that the characteristics of the crud change as the plant ages. During initial cold operation, the crud is slimy and is typical of iron hydroxide. Temperatures above 300°F cause the slimy material to rapidly become granular and more readily filterable. No data points are available prior to 110 hr. because the reactor coolant was not being circulated or sampled.

The upper curve in Figure 4 illustrates the predicted crud concentration in System B with the total purification flow of 165 gal./min. The steady-state corrosion rate was selected as 70 mg./(sq. dm.) (month), which numerous corrosion rate studies had shown to be a reasonable rate. The crud release rate was assumed to be the same. The initial peak is characteristic of initial high corrosion rates in carbon steel systems. It should be noted that the actual crud concentrations observed were all lower than the predicted values for given times.

The filter has not been operated since the plant began generating power, so no data on activity removal are available.

Figure 3 is a compilation of all the pressure drop vs. flow loading data on the hot axial flow magnetite filter. The chart indicates a difference of a factor of two between the pressure drops through clean filters containing two grades of magnetite. Both grades of magnetite had a slope of approximately 1.2, indicating that the flow was nearly laminar. There was only one occasion, during neutral pH operation in the tests, when crud caused an appreciable increase in pressure drop across the bed. Even this effect was not of major importance, since although pressure drop increased, flow could readily be maintained. Over the range of flow loadings tested, there was no apparent change in crud removal efficiency or activity removal with flow. The flow loading selected for System B was

Table 2. Magnetite and crud distribution in hot filter.
After 5 cycles on Loops 1 and 2.

Bed Position	Wt. Crud, g	% Crud	Magnetite Particle Size %: On 40 mesh	Through 40 mesh on 50	Through 50 mesh on 60	Through 60 mesh on 70	Through 70
Top quarter	4.86	3.95	1.4	39.8	22.1	16.6	19.9
Second quarter	1.37	0.88	5.3	56.3	15.9	10.3	12.3
Third quarter	1.94	1.21	8.7	55.2	15.4	10.1	10.7
Bottom quarter	2.60	1.35	11.5	52.8	15.0	10.3	10.7
Overall	10.77	1.70	7.3	51.7	16.7	11.3	12.8

Table 3. Activity removal efficiency of axial flow filter.

Period	1	2	3	4	5	6	7	8	9
Elapsed time, days	2	7	4	5	3	3	3	3	3
Inlet									
Crud concentration, ppb	37	7.0	16	15	15.4	7.8	22.2	21.3	9.6
Crud specific activity, dpm/mg. x 10^{-7}	7.64	6.0	10	10	2.5	2.1	1.5	1.55	1.88
Activity concentration product, dpm/ml.	2820	420	1600	1500	385	164	333	330	180
Water specific activity, dpm/ml	119,700	517,000	145,800	242,900	142,900	145,600	159,200	38,300	217,400
Outlet									
Crud concentration, ppb	20	20	26	24	25.2	16.1	32.6	22.0	9.0
Crud specific activity, dpm/mg. x 10^{-7}	11.2	0.76	0.75	0.75	0.26	0.34	0.19	0.13	0.22
Activity concentration product, dpm/ml.	2240	152	195	185	66	54	61	29	20
Water specific activity, dpm/ml.	96,400	456,700	110,400	182,000	100,300	157,800	125,500	29,000	179,400
Crud removal efficiency	20.6	64	88	88	81	67	82	91	89
Soluble removal efficiency, %	19.7	11.8	23.6	24.6	29.6	-9.2	21.0	23.7	17.4
Flow rate, lb./(min.)(sq.ft.)	175	175	175	175	258	258	87.5	87.5	175

near the low end of the range tested.

Backwash

Two attempts were made to displace magnetite beds from the filters. In each case, a small water stream introduced near the bottom of the filter vessel was sufficient to displace the magnetite, through another line near the bottom, as a free flowing slurry. In other tests it was found that magnetite could be displaced from a 14-in. diam. vessel, and that it could be sent short horizontal distances and long vertical distances as a slurry without difficulty. The standard backwash procedure was flow of cold water at 167-250 lb./(min.) (sq. ft), (20-30 gal./(min.) (sq. ft.) for 15 minutes. Tests of bed expansion vs. flow rate during backwashing of clean magnetite filters showed that both the Foote Mineral and J and L grades of magnetite expanded about 57% at 20 gal./(min.) (sq. ft.) and 85% at 30 gal./(min.) (sq. ft.).

Table 2 shows the variation of magnetite particle size with bed position after five run and backwash cycles in Loops 1 and 2. Concentration of small particles at the top and large particles at the bottom can be noted. This characteristic gradation is desirable since it provides better filtration at the top surface. The backwash regraded the bed with the finest particles at the top.

In those cases where pressure drop increased, backwashing lowered the pressure drop. It also removed 20 to 200% of the crud calculated to be on the magnetite, plus a large amount of fine-mesh magnetite. The bulk of the removable crud was displaced in (about) the first seven minutes of backwashing. Backwashing removed 30% of the activity calculated to be on the System A filter. It prepared the bed for further service but could not be relied upon to remove all the crud nor crud activity calculated to be on the bed. Several variations on the standard procedure were used, upon occasion. At one time, the bed on Loop 2 was backwashed at only 58 lb./(min.) (sq. ft). This removed some crud and reduced the pressure drop to that of a new bed. In System A, after a backwash at 250 lb./(min.) (sq. ft.) had removed only 30% of the activity, backwashing in short bursts at 400 lb./(min.) (sq. ft.) removed 50% more.

There was an unexplained decrease in magnetite bed volume in two tests. The considerable body of crud con-

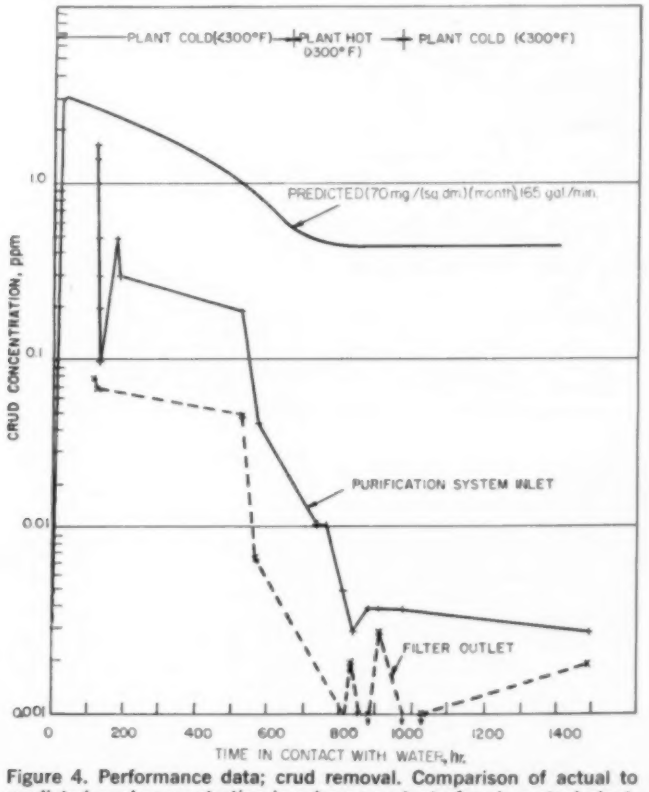

Figure 4. Performance data; crud removal. Comparison of actual to predicted crud concentration in primary coolant of carbon steel plant.

Table 4. Cold axial filter performance, Loops 1 and 2

	Bed Depth—30 in., Bed Diam.—3 in.				
Service time, hr.	300	294	326	321	304
pH	7.0	7.0	7.0	10.0	10.0
Flow loading, lb./(min.)(sq.ft.)	107	57	117	53	57
Crud removal efficiency, %	90	90	90	98	98
Initial pressure drop, ft. H_2O	20	6	15	15	15
Final pressure drop, ft. H_2O	29	37	50	42	30
Area crud loading, g/sq.ft.	440	340	120	1260	504

centration data available on the effluent water makes it appear impossible that the magnetite was lost to the plant. It seems that the decrease in bed volume is accounted for partially by compacting of the bed during service flow and partially by losses of fine material during backwashing. This decrease, if it takes place, does not create a serious problem, since the magnetite will not get into the plant, and a decrease in bed depth will not greatly impair its filtration efficiency. The data on System A demonstrated that a decrease in bed depth from approximately 18 to 13 in. did not change activity removal efficiency.

All of the tests indicated that soluble ions were leached from the magnetite. In the out-of-pile tests, sodium, calcium, aluminum, silicon, and carbonate were generally leached in detectable quantities. Sodium in the System A test increased the water specific activity during the first month of operation. Out-of-pile, the calcium and aluminum were not detected after high-pH operation started, but silica and sodium were found at high pH. Leaching of alkali (presumably carbonate) from the bed was responsible for a rise from pH 7 to pH 8.5—9.0 in Loop 3, where demineralization was poor.

Cold filter performance

The Loop 1 and 2 tests consisted of hot and cold axial flow magnetite filters. Both removed crud effectively. However, the pressure drop performance of the cold filter was greatly inferior to that of the hot filter. Since the hot filter performed successfully, and it proved unnecessary to precede an ion exchanger by a filter, no further work on the cold axial filter was attempted.

Table 4 gives some of the pertinent data on the cold axial filter performance. The most notable data are the increase in pressure drop on each run. The crud loading of 1260 g./sq. ft. for the first high pH run probably represents the maximum loading that this filter can handle. A proposed test at a flow loading above 120 lb./(min.) (sq. ft.) had to be discontinued because the pressure drop was excessive.

The effluent crud concentration from the cold axial filter was constant at 0.03—0.04 ppm during pH 10 operation and varied between 0.03 and 0.08 ppm at neutral pH. At high pH, effluent crud concentration was substantially independent of the influent crud concentration, while at neutral pH the effluent appeared to change with the influent. At comparable crud loadings on the cold filter, the pressure drop was lower at high pH than at neutral pH. The cold filter was more effective in crud removal than was the ion exchanger.

Comparison of inlet and outlet conductivities across the cold filter showed that even after 1700 hours of flow, a small amount of electrolyte was being leached from the cold filter. Backwashing of the cold filter was effective in removing crud, lowering pressure drop, and regrading the magnetite. As with the hot filter, the removable crud was released within the first few minutes of backwashing at 167 lb./(min.) (sq. ft.). Over the entire test, the amount of crud backwashed off the cold filter approximated the amount calculated to be on the filter.

The standard System A filter was operated for a short time while the magnetite filters were being tested. This filter contained sintered metal filter elements. Its plugging tendency had been the primary cause for the development of superior filters. It plugged rapidly under conditions at which the magnetite filters performed well.

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No hot axial flow filter was operated to exhaustion, so it was not possible to convert test data directly to service life. However, the test data may be interpreted to give a "worst case" predicted life which should be exceeded. The heaviest crud loading under which the filter was observed to operate well was 1400 g. crud/ sq. ft. in the first high pH test in Loop 2 (Table 1). From this loading, a theoretical operating life of eleven months can be calculated, before backwashing becomes necessary.

Conclusions

1. An axial flow magnetite bed filter will remove crud and radioactivity from a pressurized-water reactor coolant. Satisfactory, although not necessarily optimum, operating conditions are:
   a. Service flow rate of 33—260 lb./(min.) (sq. ft.)
   b. Pressure drop; See Figure 3.
   c. Water pH; neutral or high (7-10.5).
   d. Operating temperature; 500°F.
   e. Backwash method; Steady flow at 170 lb./(min.) (sq. ft.) for seven minutes or more; alternative is backwash in short bursts at higher flow loading.
   f. Maximum crud capacity; 1400 g./sq. ft.
   g. Crud leakage; depends upon crud concentration, up to 100% at 0.05 ppm; very low at 1 ppm.
   h. Minimum bed depth; 13 in.
2. Leakage of sodium from a new bed of magnetite may result in detectable levels of Na-24 in the circulating coolant. This effect should disappear after a few weeks of magnetite service.
3. Cold axial flow magnetite filters remove crud effectively but have a higher pressure drop than hot filters and are subject to plugging.
4. Magnetite filters perform equally well in neutral water and water containing LiOH or NH_4OH.
5. An axial flow magnetite filter removes some radioactivity that will pass through a filter paper.

ACKNOWLEDGMENT

All the work upon which this paper is based was carried out under prime contracts with U. S. AEC (AT-11-1 GEN-14) and U. S. Navy BuShips (NObs 67500). The author has drawn freely from the work of many engineers at the Bettis Atomic Power Laboratory.

LITERATURE CITED

1. Larson, R. E., and S. L. Williams, *Corrosion 14*, 424t-428t (Sept. 1958).

J. D. Fleming, J. W. Johnson, and H. V. Grubb

Diffusivities by tracer techniques

Radioactive tracers offer speedy and economical means to measure diffusivity quantitatively.

For many engineering problems such as leaching, drying, adsorption, dialysis, and gas effusion, effective diffusivities must be determined for fluid permeation of solids. This permeation may be either structure insensitive for a dense solid, or structure sensitive for a porous solid. In the case of structure sensitive diffusion, so many variables may influence the effective diffusivity that prediction of its quantitative value may be impossible. In such cases, experimental determination of the effective diffusivity is frequently the only recourse.

Experimental determination of effective diffusivities generally involves a chemical analysis and, although accurate, is relatively expensive and time consuming. The accuracy of the chemical method is often unwarranted in view of the limits of reproducibility of the diffusion system itself.

Tracer techniques provide means for an economical solution of many engineering problems (*1*). In the work reported here, a labeled diffusing gas was used as the basis of a simple, relatively inexpensive system for the quantitative determination of effective diffusivities. This technique has the additional advantage of being usable at elevated temperatures since no sample need be withdrawn for analysis and no probe actually enters the system.

Method

A permeation system was constructed for the determination of effective diffusivities for krypton flow through porous slip-cast fused silica at room temperature. The system consisted simply of two 2-in. I. D. Pyrex pipe crosses between which the silica sample was clamped. Interface gaskets of overplasticized polyvinyl chloride were used to form a gas-tight seal between the silica disc and the Pyrex crosses. The upper leg of each cross was fitted with valves to allow the crosses to be emptied by water displacement. A schematic diagram of the system is shown in Figure 1.

In an experiment, a glass ampoule containing about 3 mc of krypton 85 was placed in the hot cross*, the closure plates bolted on, the ampoule crushed by a plunger, and the total pressure in each cross adjusted to one atmosphere. The activity in each cross was measured as a function of time, using conventional Nuclear Chicago counting equipment with Geiger detectors. Because the silica sample was sufficiently thick to attenuate the betas, the Geiger tubes were unable to "see" the activity in the opposite cross. As a result, no correction for changing background was necessary. The characteristics of the counting system and background were the same for both crosses.

The tracer gas activity in a cross would be proportional to the number of tracer gas molecules in that cross, so that

$$a = K_1 n \qquad (1)$$

Since, in the system used, the counting geometry and counting system characteristics were the same for both crosses, the same proportionality constant, K_1, would apply to both the hot side and the cold side.

The unsteady state diffusion through the silica follows Equation 2.

$$\frac{\partial C}{\partial \theta} = D\frac{\partial^2 C}{\partial x^2} \qquad (2)$$

The boundary conditions applying to this problem are:

a. $C\,(0, 0) = 0$
b. $C\,(L, 0) = K_1$
c. $C\,(0, \theta) = f_1\,(\theta)$
d. $C\,(L, \theta) = f_2\,(\theta)$

Consideration of Equation 2, under the stated boundary conditions, shows that it is not amenable to simple solution. Solution of even a simplified case similar to these conditions (*3*) leads to error functions of complex argument which have not been tabulated. Consideration of a much less complex problem will indicate that solution of the preceding problem is unnecessary.

Consider a plane slab through which a gas is diffusing from $x = L$ to $x = 0$. For an isotropic solid, this diffusion is represented by Equation 2. Prior to $\theta = 0$, the concentration through the solid is a linear function of x. At all times the concentration at $x = 0$ is constant. At $\theta = 0$, the concentration at $x = L$

* *Hot and cold will refer to the level of radioactivity in the crosses.*

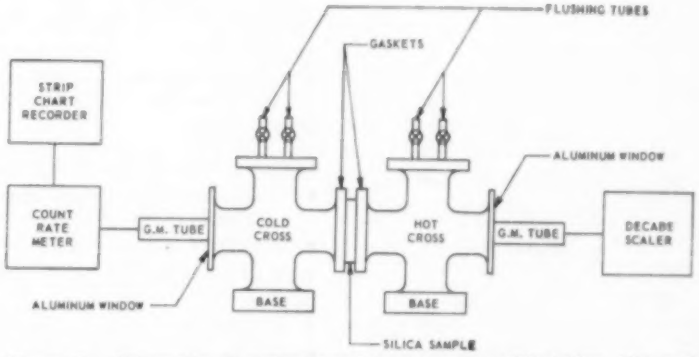

Figure 1. Schematic of system used to determine diffusivities. Hot and cold designations refer to level of radioactivity in the crosses.

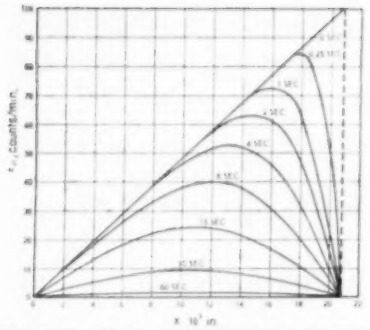

Figure 2. For an instantaneous change in hot side activity of 100 counts/min. with constant cold side activity of 0 counts/min., the concentration gradient through a ¼-in. slab of silica reaches equilibrium in about 1 min.

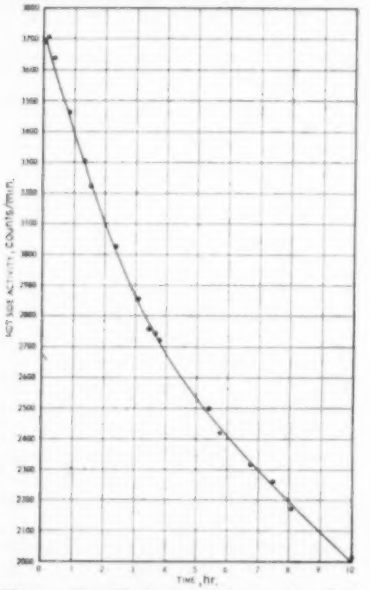

Figure 3. Maximum change in hot side activity during first hour of operation is about 300 counts/min.

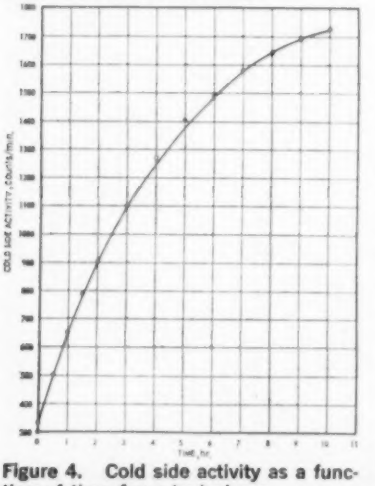

Figure 4. Cold side activity as a function of time for a typical run.

is suddenly changed from a constant value K', to a new constant value K_2'.

e. $C\,(L, \theta) = K_2'$

f. $C\,(x, 0) = K_3'x$

g. $C\,(0, \theta) = K_4'$

Converting Equation 2 and boundary conditions e, f, and g to activity, rather than concentration, using Equation 1 yields

$$\frac{\partial a}{\partial \theta} = D\frac{\partial^2 a}{\partial x^2} \qquad (3)$$

and

h. $a\,(L, \theta) = K_2$

i. $a\,(x, 0) = K_3x$

j. $a\,(0, \theta) = K_4$.

Assuming that the activity may be separated into two terms, a_I representing the steady state activity at infinite time, and a_{II} representing the deviation from steady state at any time and position,

$$a_I = \phi(x)$$
$$a_{II} = \phi(x, \theta)$$

If

$$a = a_I + a_{II} \qquad (4)$$

then

$$\frac{\partial a_I}{\partial \theta} = D\frac{\partial^2 a_I}{\partial x^2} \qquad (5)$$

and

$$\frac{\partial a_{II}}{\partial \theta} = D\frac{\partial^2 a_{II}}{\partial x^2} \qquad (6)$$

NOTATION

A = area of porous slab perpendicular to direction of tracer gas flow, sq. ft.

a = tracer gas activity in cross, counts/min.

C = tracer gas concentration, lb. mole/cu. ft.

D = effective diffusivity, sq. ft./hr.

G = net flow rate of tracer gas, lb. mole/hr.

K = constant

L = thickness of porous slab, ft.

n = number of tracer gas molecules in cross

v = volume of cross, cu. ft.

x = distance through porous slab from cold side, ft.

θ = time, hr.

Subscript C = cold side

Subscript H = hot side

Since a_I is the steady state activity, the solution of Equation 5 is obviously

$$a_I = K_4 + \frac{(K_2 - K_4)x}{L} \qquad (7)$$

The Solution of Equation 6* is

$$a_{II} = \sum_1^\infty b_n \sin\frac{n\pi x}{L} e^{-\frac{Dn^2\pi^2\theta}{L^2}} \qquad (8)$$

in which

$$b_n = \frac{2}{L}\int_0^L (a_{II})_{\theta=0} \sin\frac{n\pi x}{L}\,dx \qquad (9)$$

From boundary condition i and Equation 4,

$$(a_{II})_{\theta=0} = K_3x - (a_I)_{\theta=0}$$

and, since a_I is independent of time,

$$(a_{II})_{\theta=0} = K_3x - K_4$$

$$-\frac{(K_2 - K_4)}{n\pi}(-1)^{n-1} \qquad (10)$$

Integration of Equation 9 following substitution of Equation 10 yields

$$b_n = \frac{2K_3L}{n\pi}(-1)^{n-1}$$

$$+\frac{2K_4}{n\pi}[(-1)^{n-1} - 1]$$

$$-\frac{2(K_2 - K_4)}{n\pi}(-1)^{n-1} \qquad (11)$$

And, from Equations 4, 7, and 8, the general solution for Equation 3 is, under boundary conditions h, i and j,

$$a = K_4 + \frac{(K_2 - K_4)x}{L}$$

$$+\sum_1^\infty b_n \sin\frac{n\pi x}{L} e^{-\frac{Dn^2\pi^2\theta}{L^2}} \qquad (12)$$

For short periods of time, Equation 8 converges slowly. To indicate the response of the diffusion system, a_{II}, the deviation at any time from the activity distribution at $\theta = \infty$, was calculated by programming Equation 8 for IBM-650 computation to within approximately 1% of the true analytical value. For a 0.25-in. thick silica slab, used in most of the tests, with a representative effective diffusivity of 10^{-2} sq. ft./hr., Figure 2 shows a_{II} for an instantaneous change in hot side activity from 4000 counts/min. to 3900 counts/min. and a con-

* *The convergence and validity of this solution is discussed by Carslaw and Jaeger (3).*

stant cold side activity of 0 counts/min.

Figure 2 shows that the concentration gradient through the slab would essentially reach equilibrium in approximately one minute, following the instantaneous hot side activity decrease of 100 counts/min. Figure 3, which shows the change in hot side activity with time in a typical run, indicates that the maximum rate of hot side activity change, occurring during the first hour of operation, is approximately 300 counts/min./hr. The concentration gradient is thus seen to approach linearity at a rate which greatly exceeds the rate of hot side activity change. Under these circumstances, in the system used, the concentration should be very nearly a linear function of position at all times and the system should be adequately represented by the steady state diffusion equation.

$$G = -DA\frac{dC}{dx} \qquad (13)$$

which, for a plane slab, yields the integral equation

$$G = \frac{DA}{L}(C_H - C_C) \qquad (14)$$

Since

$$G = \frac{dn_C}{d\theta} \qquad (15)$$

Equation 12 may also be written

$$\frac{dn_C}{d\theta} = \frac{DA}{L}(C_H - C_C) \qquad (16)$$

Flemming

Johnson

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or since

$$C = \frac{n}{v},$$

$$\frac{dn_C}{d\theta} = \frac{DA}{LV}(n_H - n_C) \qquad (17)$$

Substituting Equation 1 in Equation 17 gives

$$\frac{da_C}{d\theta} = \frac{DA}{LV}(a_H - a_C) \qquad (18)$$

If the diffusion process actually follows a steady state behavior and if the solid being permeated is actually isotropic, Equation 18 indicates that a plot of the slope of the curve of cold side activity vs. time, as a function of the difference in hot and cold side activities, should yield a straight line passing through the origin. The slope, DA/LV, of this line would permit calculation of the effective diffusivity.

Two advantages accompany this method of treating the data. Equation 18 shows that no correction of the data for background is necessary. The background would cancel in the activity difference term, since systems with similar counting characteristics were used, and would not appear in the term for differential cold side activity change. In addition, no knowledge is required of the specific activity of the tracer gas or of the exact quantity of tracer gas used. Since Kr-85, with a half life of 10.3 yr., was used as the tracer, no correction for radioactive decay was required.

Results

A series of silica discs, 3-in. diam. by ¼-in. thick, was fabricated by slip casting. These discs were subjected to permeation by Kr-85, as described above.

Figures 3 and 4 show the hot and cold side activities as functions of time for a typical run on a disc fired at 2200°F for four hours. Graphical differentiation of Figure 4 gave the plot of differential activity change as a function of time shown in Figure 5. Figure 6 illustrates the relationship between this differential activity change and the difference in hot and cold side activities. As Equation 18 predicts, a straight line results which does pass through the origin. For this run, the effective diffusivity is given by

$$D = \text{slope of Figure 5} \times \frac{LV}{A}$$

$$= 0.102\ \text{hr.}^{-1}\left(\frac{0.0208\ \text{Ft.} \times 0.0266\ \text{Ft.}^3}{0.00545\ \text{Ft.}^2}\right)$$

$$= 1.04 \times 10^{-1}\ \frac{\text{ft.}^2}{\text{hr.}}$$

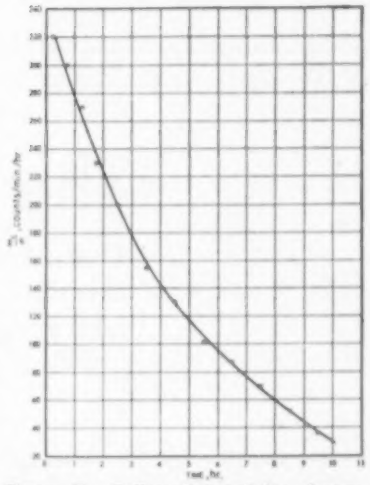

Figure 5. Differential activity change as a function of time by graphical differentiation of Figure 4.

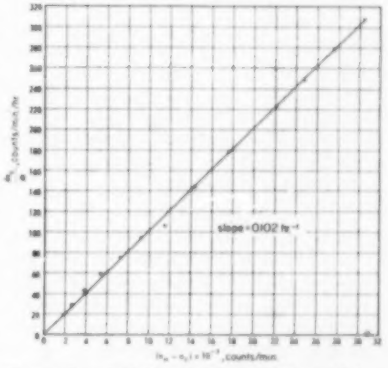

Figure 6. Relation between differential activity change and difference in hot and cold side activities.

The use of a radioactive tracer fluid permits effective diffusivities to be quantitatively measured. In many cases, only a simple graphical procedure is required for correlation of the data. The method offers advantages of economy and speed over conventional methods using chemical analysis and shows good potential for simple high temperature measurement. No measurement of specific activity or exact tracer gas quantity is required.

ACKNOWLEDGMENT

The work described in this paper was supported by U.S. AEC under Contr. No. AT-(40-1)-2483.

LITERATURE CITED

1. McCormick, J. A., "Bibliography on Uses of Radioactive and Stable Isotopes in Industry", TID 3511, U.S. AEC (July, 1957).
2. Treybal, R. E., "Mass Transfer Operations", Ch. 4, McGraw-Hill, New York (1955).
3. Carslaw, H. S. and J. C. Jaeger "Conduction of Heat in Solids", Sect. 21, 34, Oxford Univ. Press, London (1948).

V. W. Uhl and H. P. Voznick

The anchor agitator

Use it for heat transfer and batch mixing. Use this data for correlating clearances, power and heat transfer rates.

The anchor agitator has been used widely for the batch mixing and heating of viscous fluids, slurries, and materials which change consistency during the process cycle. Cross members are generally required for structural reasons as shown in Figure 1a. Sometimes paddles are added to provide additional agitation in the core of the material. This additional agitation can also be furnished by vertical fingers in a gate-type anchor shown in Figure 1b. A paddle-anchor combination is shown in Figure 1c.

The clearance between the outer edge of the anchor agitator and the vessel wall is generally of the order of ¼ to ⅜ in. (*12*) to several inches (*1*). However, blades which scrape the heating surface are found to be necessary when an adhering layer of solids accumulates on the wall surfaces or when the material cannot be impelled for any significant distance by the motion of the agitator because of high fluid consistency. Two typical scraper arrangements are shown in Figure 2. In one case the scraper is pressed against the wall by spring action of the blade. In the other example, the blade is hinged on the agitator and fluid pressure forces the blade edge to contact and scrape the heat transfer surface as the agitator revolves.

It is generally recognized that slow-moving agitators with large surface areas are needed to mix and perform other operations in the processing of viscous materials. The inadequacy of high-speed agitators for these tasks has been effectively demonstrated by Metzner and co-workers (*6, 7*). The anchor and its modifications occupies the position of the appropriate agitator for materials having consistencies between mobile fluids and extremely high-consistency materials which are generally plastic in character.

To date it appears that the quantitative information for the anchor agitator has been limited to the work of Huggins (*3*), Brown *et al.* (*1*), Uhl (*14*), and Foresti and Liu (*2*). The significant variables of anchor agitator operation for which no information was available were investigated in this work. This included clearance, system geometry, and width of agitator blades on both power and heat transfer. For the study, the 50-gal. conventional dished-head kettle, used by Uhl, and a 2-gal. shallow vessel with a flat bottom were used.

Significant dimensions and the range of test conditions are given in Table 1. The liquid used for all tests was Pennsylvania cylinder oil. The properties of the cylinder oil appear in Table 2 over the temperature range of use. The 50-gal. unit is described in detail in (*14*) and the scheme used for power measurement is presented in (*15*). For the 2-gal. unit, power input was found from the torque exerted by the turn table on which the agitator drive was mounted.

The power runs were made under isothermal conditions. The heat transfer runs were made batchwise by heating or cooling the vessel contents. The heat transfer runs were divided into a number of shorter periods of 10- to 15-min. duration. The basis for calculation and the values used for the jacket film coefficient are given in (*14*).

The work input by the agitator was sufficiently small to be neglected. Also, heat losses from the surface of the fluid were considered to be negligible. At low speeds (8-11 rpm) a tendency to stratify was noted by a temperature difference of 2 to 3°F from the top to the bottom of the test oil in the 2-gal. vessel. No such indication of stratification was observed for the 50-gal. unit.

Power results

The power data were correlated by plotting the Power number vs. the Reynolds number, with clearance as the parameter. The data for the 50-gal. kettle are presented in Figure 3. These include values for clearances of ¼- and 1-in. of this work, plus the ⅜-in. reported previously by Uhl for the same system. Data for the 2-gal.

Table 1. Vessel and operational data.

Nominal vessel capacity	50 gallon	2 gallon
Bottom head type	ASME flanged and dished-head	Flat
Inside diam. of vessel	23⅜ in.	10¾ in.
Liquid depth for tests	28⅝ in.	5-3/16 in.
Liquid capacity for tests	50 gal.	1.78 gal.
Effective heat transfer area	Approx. 15 sq. ft.	1.73 sq. ft.
Blade widths	2 in. and 3 in.	1 in.
Vertical height of agitator	21 in.	5-3/16 in.
Agitator height/Agitator diam.	0.89	0.50
Blade clearances	¼, ½[a], ¾, 1 in.	3/32, ¼, ⅜, ½ in.
Speed range for tests	22[b] to 75[c] rpm	8.8 to 66 rpm
Temperature range	81 to 204°F	85 to 215°F
Corresponding viscosity range	0.6 to 30 poises	

[a] Used by Uhl (*14*) and given in his work as 7/16 in.
[b] Minimum speed investigated by Uhl (*14*) was 50 rpm.
[c] This corresponds to maximum speed for anchors given in trade literature as 450 lineal ft./min. (*4*).

vessel are presented in Figure 4 for clearances of 3/32, ¼, ⅜ and ½ in. These curves show an increase in power requirements with decreasing blade-to-wall clearance as a result of increased viscometric drag. The data at Reynolds numbers above 1000 (Figure 3) indicate that the turbulent region is being approached and at this point the effect of clearance on power diminishes, as might be expected, due to the introduction of eddy formation and the disappearance of a viscometric drag effect. Also, where the Reynolds number is very roughly of the order of 1000, vortexing develops.

The range of Reynolds number for the 2-gal. unit was 2 to 80, and the curves through the data were drawn with a slope of −1.0. This is expected for a power relation in the viscous regime. The power data for the 50-gal. unit fall in a higher Reynolds number range, giving a slope of −0.75 which indicates the transition regime.

The effect of clearance on power consumption is correlated in Figure 5 by plotting the Power number against the dimensionless ratio, C/D, clearance over kettle diameter, at a Reynolds number of 20, which is in the viscous regime and common to the results from both vessels. Better agreement was obtained by using C/D rather than the absolute value of clearance, C. The 24-in. unit shows higher power numbers at a given C/D ratio and Reynolds number; this is reasonable because of the greater height-to-diameter ratio of the agitator in the larger vessel. The relative position of the power curves for each unit and their slope can be compared by referring to Figure 6, where a curve for each vessel is plotted for a C/D of 0.02.

It was possible to compare these results for the 2-gal. unit with the power curve obtained by Foresti and Liu (2) for the only Newtonian fluid (300 poise viscosity) which they investigated. Their anchor had a clearance of 3/16-in. in an 11½-in. diameter vessel, which gave a clearance factor of 0.016. Also, the height of the agitator was about 6-in. which compares with the anchor height of 5-3/16-in. for the 2-gal. unit. This power curve of Foresti and Liu for a Reynolds number range of 0.1 to 10 was parallel to the curve in Figure 4, and was located about 30% above the curve for the corresponding clearance factor of 0.016, thereby serving as a rough check for the correlation for the 2-gal. unit.

The discrepancy between the data for the two test units in Figure 6 can be reconciled, at least for the short range of Reynolds numbers common to both curves, by reducing the Power number to a consistent peripheral length basis. To do this it must be recognized that viscometric drag accounts for most of the power drawn and this depends on the length of the outer edge of the anchor blade, the area swept, and blade velocity. Since the bottom blade sweeps only one-half the area of a side blade in one revolution and since its velocity varies from that at the side wall to zero at the center, a rigorous calculation gives the power drawn for the bottom blade as one-quarter that for one side wall blade of height equal to the vessel diameter. This suggests a factor

Table 2. Properties of test oil. Pennsylvania cylinder oil (Socony Vacuum No. 717).

Temp. °F	Specific gravity 60/60°F	Viscosity, centistokes	Viscosity, lb./(ft.)(hr.)	Specific heat Btu/(lb.)(°F)	Thermal cond., Btu/(hr.)(°F)(ft.)	Prandtl number
70	0.909	5800	12,740	0.434	0.0793	69,600
100	0.897	1535	3330	0.450	0.0788	19,000
130	0.885	509	1089	0.466	0.0783	6490
160	0.873	215	455	0.483	0.0778	2825
190	0.861	103	214	0.499	0.0773	1380

Figure 1a. Typical anchor agitator showing structural cross members.

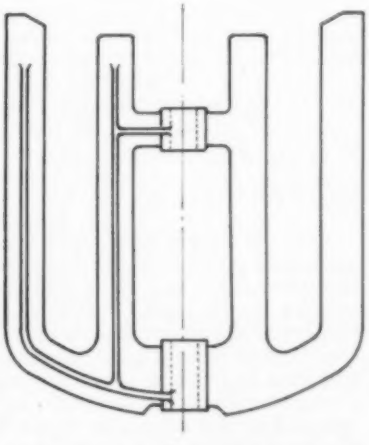

Figure 1b. Gate type anchor agitator used to provide additional agitation at the core of the material.

Figure 1c. Paddle-anchor combination agitator.

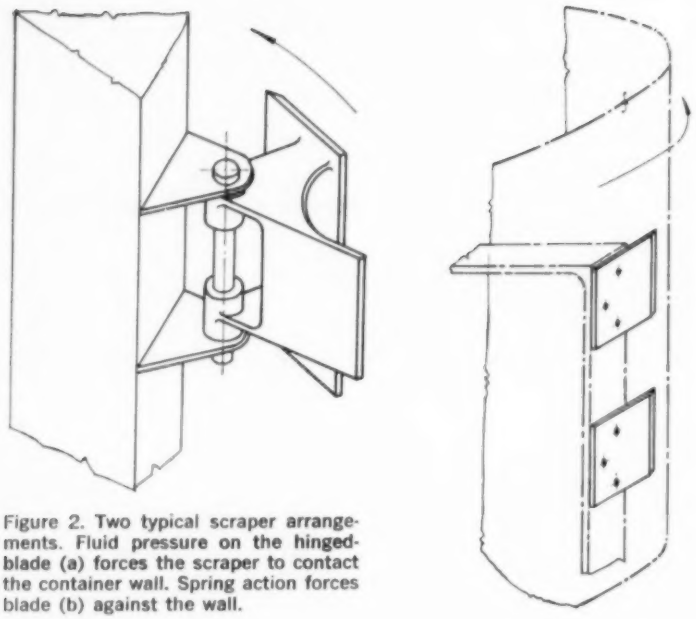

Figure 2. Two typical scraper arrangements. Fluid pressure on the hinged-blade (a) forces the scraper to contact the container wall. Spring action forces blade (b) against the wall.

for correcting the Power numbers to a consistent basis by dividing an "effective peripheral length" (EPL) by the vessel diameter, D, where the EPL is the length of the two vertical blades plus one-quarter the length of the bottom blade. Therefore, at a Reynolds number of 20, where the Power number of the 50-gal. unit is 18 for an effective liquid depth of 21 in., the EPL/D factor is

$$2\left(\frac{21}{23\frac{1}{8}}\right)+\frac{1}{4}\left(\frac{23\frac{1}{8}}{23\frac{1}{8}}\right)=2.04$$

to give a corrected Power number of $18/2.04 = 8.9$. Similarly, for the geometry of the 2-gal. unit, the EPL/D factor is

$$2\left(\frac{5\text{-}3/16}{10\frac{1}{4}}\right)+\frac{1}{4}\left(\frac{10\frac{1}{4}}{10\frac{1}{4}}\right)=1.25$$

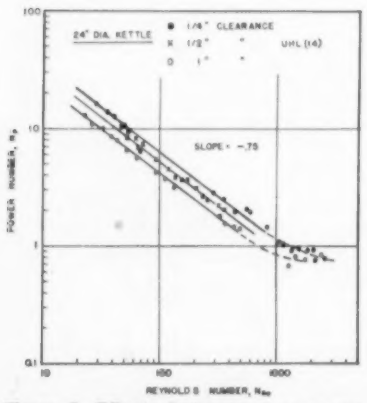

Figure 3. Effect of clearance on power drawn: 24-in. diam kettle.

to correct the Power number of 12 for a Reynolds number of 20 to $12/1.25 = 9.6$ This is a reasonable check. This kind of analysis was used by the second author in calculating the power drawn by the bottom anchor in the paddle-anchor agitator shown in Figure 1c.

Power data for blade width for 3 in. are given along with those for 2 in. in Figure 7. The clearance was ½ in. and values for bodied linseed oil are also included for the 2-in. blade. There appeared to be no marked effect of changing blade width. This is reasonable because of the absence of shear forces in the direction in which the blade was widened. This should be contrasted with the effect of clearance which is marked because of its influence on viscometric drag. In this connection, it is to be noted that the blade width-to-diameter ratio for the 50-gal. kettle is 2/23⅛, or 0.085, which is about the same as 1/10¼, or 0.098, for the 2-gal. unit.

Heat transfer results

Values of h_j, the vessel fluid film coefficient, were calculated from the experimental data using the procedure outlined in (*14*). Then h_j was combined with the other values to calculate the heat transfer factor J', which is defined in Notation. The values of J' calculated from the data are plotted against Reynolds number in Figure 8 for the clearances of ¼, ½, and 1 in. These curves are separated to show the pattern of the data. The curves which best describe the data for each clearance in the 2-gal. kettle are presented in Figure 9.

These data are compared effectively in Figure 10, where the J' values are plotted against clearance factor, C/D, for given values of Reynolds number for both units. A somewhat unexpected conclusion is drawn from these curves. For the range of clearance studied, the rate of heat transfer as indicated by J' decreases at first with increased clearance and then increases with further increase in clearance. Data for Power number similar to that in Figure 5 are included in Figure 10 for comparative purposes.

The data of Brown *et al.* (*1*) indicated that for a 5-ft. diam. kettle in sulfonation service, the rate of heat transfer with 5-in. clearance was about 20% better than with 1-in. clearance. This shows that the increase in heat transfer rate with clearance also occurs for the higher Reynolds numbers of 5500 to 37,000 of their work.

The work of Huggins (*3*) provides a check on the indication that the heat transfer rates are higher at very close clearances. Table 3 presents a summary of results from Huggins' work. This compares rates of heat transfer to various materials in a Dopp kettle equipped with a double-motion agitator and tested with and without scrapers. Without scrapers the agitator might be considered to be equivalent to an anchor but with very intense agitation of the core. The clearance when no scrapers were used was 7/16 in., which with a vessel diameter of 2.25 ft. gives a clearance factor of 0.016. This corresponds roughly to the C/D value giving minimum rate of heat transfer as shown in Figure 10. The enhance-

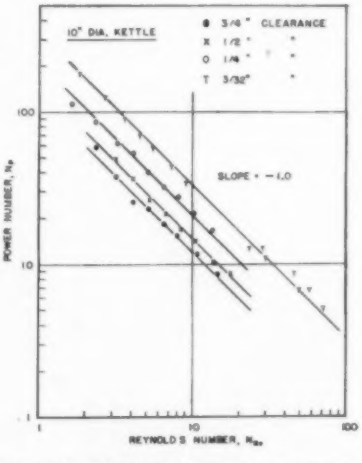

Figure 4. Effect of clearance on power drawn: 10-in. diam. kettle.

Notation

Symbol	Definition	Units
C	= Clearance of anchor agitator from jacket side and bottom	ft.
c	= Specific heat	Btu/lb. (°F)
D	= Kettle diameter	ft.
EPL	= Effective peripheral length	ft.
g	= Gravitational constant	(ft./sec.)/sec.
h_j	= Coefficient of heat transfer, kettle liquid to jacket wall	Btu/(hr.)(sq. ft.)(°F/ft.)
J'	= Heat transfer factor	dimensionless, see below
k	= Thermal conductivity	Btu/(hr.)(sq. ft.)(°F/ft.)
L	= Impeller diameter	ft.
N	= Rate of impeller rotation	rev./sec.
P	= Power input	ft. lb./sec.
μ	= Viscosity in body of liquid	(lb.)/(sec.)(ft.)
μ_w	= Viscosity at wall surface	(lb.)/(sec.)(ft.)
ρ	= Density of kettle liquid	lb./cu. ft.
$\frac{C}{D}$	= Clearance ratio	
N_P	= Power number	$\frac{Pg}{\rho N^3 L^5}$
N_{Re}	= Reynolds number	$\frac{L^2 N \rho}{\mu}$
$\frac{\mu_w}{\mu}$	= Viscosity ratio	
J'	= Heat transfer factor	$\frac{\left(\frac{h_j D}{k}\right)\left(\frac{\mu_w}{\mu}\right)^{0.18}}{\left(\frac{c\mu}{k}\right)^{1/3}}$

ment of heat transfer by the scrapers for the Newtonian fluids was 1/7 to 1/2 higher than without scrapers, which confirms the trend indicated in Figure 10. As might have been expected, the use of scrapers enhances rate of heat transfer to the non-Newtonian fluids (presumably pseudoplastic) to a much greater extent, namely four to five times.

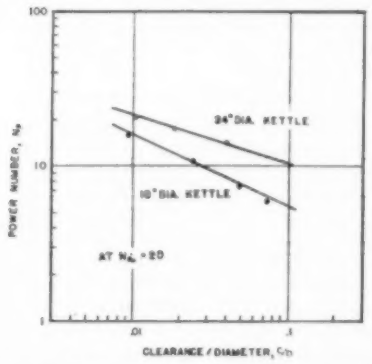

Figure 5. Effect of clearance factor on power drawn: 10- and 24-in. diam. kettles.

Apparently, at small clearances the liquid layer between the blade and wall is in streamline flow and the blade serves to scrape the material up to the outer edge of the blade and mix it with the bulk of the fluid. Therefore, as the clearance increases the rate of heat transfer drops because of the increased laminar layer. Then, as the value of the clearance is increased beyond a critical value, which appears to be a function of the clearance ratio, C/D, the rate of heat transfer improves. The only reasonable explanation for this phenomenon is that turbulence is developed between the blade and the wall when the clearance exceeds the critical value. There is some suggestion of such eddy formation from the work of Taylor (*13*) who reports on the formation of vortexes for rotational flow between concentric cylinders as the clearance is increased.

Unfortunately, there are no data for clearance ratios greater than shown on Figure 10. However, it seems safe to assume that the value of J' would eventually decrease as the clearance factor continued to increase, probably beyond 0.10. From the data available, it is apparent that for Newtonian liquids the rate of heat transfer is 20 to 30% greater for C/D of 0.05 to 0.08 than for C/D of 0.02 to 0.05. Furthermore, this increase appears to hold for Reynolds numbers from 10 to 37,000.

The heat transfer results from this and the previous work in the 50-gal. unit are presented in the conventional form in Figure 11, where no attempt is made to show the effect of the clearance factor. The effect of relative height of the vessel fluid exhibited no marked effect on the rate of heat transfer as it did for power consumption.

Anchor agitator effectiveness

The anchor is particularly effective in heat transfer, but also in other operations for liquids having viscosities in the range of 1.0 to 1000 poises. Several references (*5, 9, 10*) have indicated the turbine, paddle, and to some extent the propeller, as suitable for use in this viscosity range. Two items of available information on this subject demonstrate that these impellers as conventionally used would be inadequate, certainly for the higher viscosities. When Metzner (*6, 7*) rotated a flat-bladed turbine in corn syrup and a high consistency solution of sodium-carboxyl-methyl-cellulose in water, he noted that only the material in the vicinity of the impeller was moved and that the flow pattern was streamline. Uhl (*16*) compared an anchor with a large turbine and paddle, using as the mixing characteristic the coincidence of top and bottom temperature when transferring heat. As expected, the anchor was more effective, for example, at 50 rpm it completely mixed 40-poise liquid, as compared with a maximum of 15-poise material mixed by the large tur-

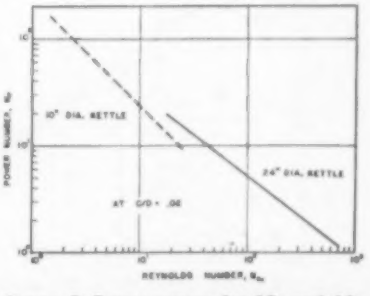

Figure 6. Power curves for 10- and 24-in. diam. kettles at C/D factor of 0.02.

Table 3. Comparison of heat transfer with scraping vs. close clearance[a] agitators.
Data of Huggins (3)

Double-motion agitation — Speed of outer agitator—15 rpm
Average diam. kettle—2.25 ft. — Speed of inner agitator—25 rpm

Operation	Character of fluid	Viscosity range for test, cp.	Approx. increase in rate of heat transfer scraping vs. close clearance
Heating	Medium motor oil	Newtonian	10-100	1/7
Heating	Paraffin-base Aircraft oil	Newtonian	10-300	1/4
Heating	Mixture of aluminum oleate and oil	Non-Newtonian	400-2500	5
Cooling	Chocolate syrup[b]	Assumed Newtonian	....	1/2
Cooling	No. 3 cup grease	Non-Newtonian	....	4

[a] *For close clearance, clearance was 7/16 in.*
[b] *Essentially a sugar syrup.*

bine and paddle. The mixing performance of the anchor would have been better if it had cross members or vertical fingers, Figure 1b, which would have thoroughly agitated the core.

A comparison of the heat transfer rates for given power inputs was made for the anchor, paddle, and turbine by Uhl (*14*) where the data overlap. At a given power input, it was shown that one impeller is about as satisfactory as another for promoting heat transfer. However, as discussed in this work, the choice of an impeller is dictated mostly by the consistency range of the fluid.

The anchor becomes ineffective for materials having very high viscosities because, in addition to shearing at the wall, it does depend on its ability to impart velocity to the fluid in the vicinity of the blade. This is virtually impossible for fluids having viscosities over about 1000 poises. Since the mixing of these materials is generally further complicated by a non-Newtonian character (generally pseudo-plastic), mixing action for these highly viscous materials must be promoted entirely by actions such as shearing, wiping, folding, and stretching. These operations are carried out in kneaders, masticators, and mullers.

Design recommendations

The anchor agitator (in one of its modifications) should be used for heat transfer to liquids of medium to high viscosities. It should be considered for other operations, especially the suspension of solids and blending of high-consistency liquids.

For heat transfer to Newtonian material, a clearance factor, C/D, of 0.05 to 0.08 will give better heat transfer rate at a lower power requirement than a C/D of 0.01 to 0.02, which yields clearances of the range commonly used. A blade width 1/12 of the kettle diameter should be satisfactory. Peripheral speed should not exceed 450 ft./min. (*4*). Another limiting condition is a Reynolds number of very roughly 1000, at which vortexing is anticipated.

For heat transfer to pseudo-plastic, or other non-Newtonian liquids having a behavior index less than 1.0, either very close clearance or a scraper agitator should be used. Also, close clearance or positive scraping is necessary when a more viscous or solid layer deposits on the wall. An example of the need for close clear-

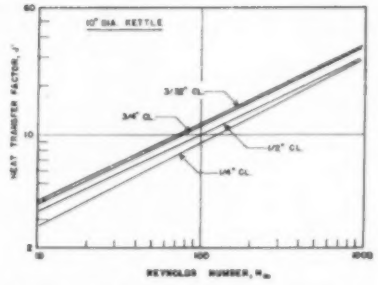

Figure 9. Effect of clearance on heat transfer in 10-in. diam. kettle.

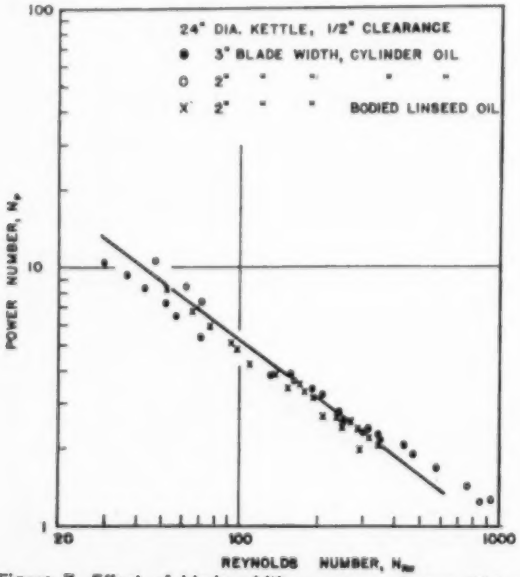

Figure 7. Effect of blade width on power drawn: 24-in. diam. kettle.

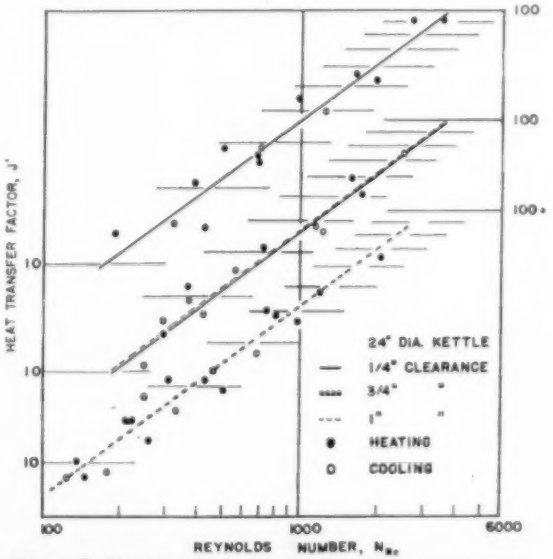

Figure 8. Heat transfer at various clearances in 24-in. diam. kettle.

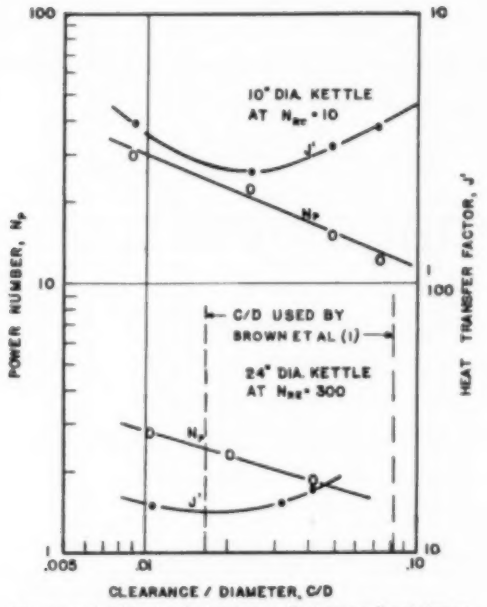

Figure 10. Effect of clearance factor on heat transfer factor and power number: 10- and 24-in. diam. kettles.

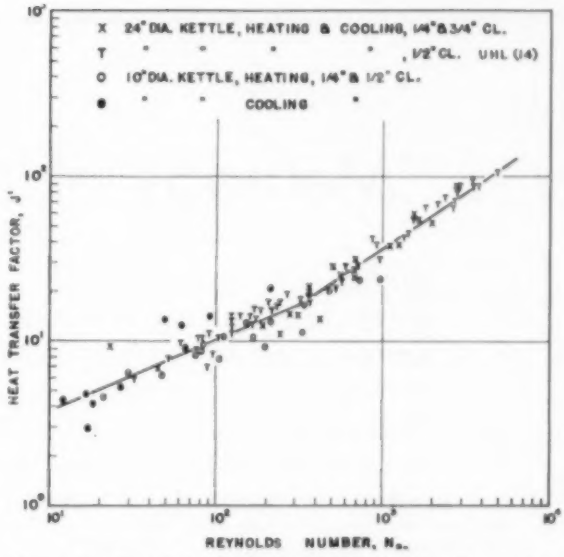
X 24" DIA. KETTLE, HEATING & COOLING, 1/4" & 3/4" CL.
Y " " " " , 1/2" CL. UHL (14)
O 10" DIA. KETTLE, HEATING, 1/4" & 1/2" CL.
● " " COOLING "
HEAT TRANSFER FACTOR, J'
REYNOLDS NUMBER, N_{Re}

Figure 11. Overall heat transfer correlation for the anchor agitator: 10- and 24-in. diam. ketties.

ance is given by Riddle (*11*). In the polymerization of acrylic materials, where the viscosity is 15 to 200 poises, an agitator having a clearance not to exceed ⅜ to ¼ in. was recommended to "prevent the formation of a static layer of viscous solution which, if left undisturbed may bake to an insoluble gel capable of acting as an efficient heat transfer insulation."

For liquids in the lower viscosity range of 1.0 to 10 poises, the plain horseshoe will be satisfactory. For 10 to 100 poises, cross members with pitched-blade or vertical legs, as in the gate-type agitator (see Figure 1b), are necessary to obtain the necessary mixing of the core of the material. For viscosities over 100 poises, either stationary baffles attached to the cover, or double-motion agitators, should be used. The power drawn by cross members, such as paddles and vertical fingers, should be added to the value calculated for the anchor.

The power drawn can be calculated from Figure 6, with corrections for the effect of clearance which can best be taken from Figure 5. Variations in agitator height can be allowed for by determining the effective peripheral length to diameter ratio, EPL/D, as developed above, and correcting the Power number for the appropriate Reynolds number, noting that the EPL/D ratio was 2.04 for the 50-gal. and 1.25 for the 2-gal. geometry.

Since the data gathered in this work covered a 25-fold range in volume with consistent results, scale-up to 1250-gal. vessels from the 50-gal. test data can be expected to give reasonable values.

When heat transfer surface in addition to that from the jacket is needed, as in scaling up pilot plant equipment, internal coils can be added. A suggested scheme is an anchor between the coil and jacket with one or more pitched-blade paddles inside the coil on the common shaft. The value of the film coefficient to the coil, using the anchor, can be approximated from the relation by Oldshue and Gretton (*8*) on the assumption that the heat transfer relation for the turbine and anchor coincide for coils, which was shown to be roughly the case for jackets (*14*). In this scheme the power consumption by the anchor would be expected to be about twice that calculated for a vessel without coils.

Uhl

Voznick

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ACKNOWLEDGMENT

The experimental work in the 2-gal. unit was carried out by E. G. Fleck under direction of the senior author under a grant by Bethlehem Foundry and Machine Company to the R. & D. Div., Villanova Univ. The 50-gal. unit was made available for this work by the Ch. E. Dept. at Lehigh Univ.

LITERATURE CITED

1. Brown, R. W., R. Scott, and C. Toyne, *Trans. Inst. Chem. Engrs.*, *25*, 181 (1947).
2. Foresti, R., Jr., and T. Liu, *Ind. Eng. Chem.*, *51*, 860 (1959).
3. Huggins, R. E., *Ind. Eng. Chem.* *23*, 749 (1931).
4. International Engineering, Inc., "International Mixing and Process Equipment," Cat. No. 101, p. 28, Dayton, Ohio.
5. McCabe, W. L., and J. C. Smith, "Unit Operations of Chemical Engineering," p. 282, McGraw-Hill Book Co., (1956).
6. Metzner, A. B., and R. E. Otto, *A.I.Ch.E. J.*, *3*, 3 (1957).
7. Metzner, A. B., and J. S. Taylor, "Flow Patterns in Agitated Vessels," submitted to *A.I.Ch.E. J.*
Westwater, J. W., *Chem. Eng. Prog.* *55*, 49 (June, 1959).
8. Oldshue, J. Y., and A. T. Gretton, *Chem. Eng. Prog.*, *50*, 615 (1954).
9. Perry, J. H., "Chemical Engineers' Handbook," 3 ed., p. 1216-1219, McGraw-Hill Book Co., (1950).
10. Quillen, C. S., *Chem. Eng.*, *61*, (6): 178 (1954).
11. Riddle, E. H., "Monomeric Acrylic Esters," p. 46, Reinhold (1954).
12. Riegel, E. R., *Chemical Process Machinery*, 2 ed., p. 283, Reinhold (1953).
13. Taylor, G. I., *Trans. Roy. Soc. (London)*, *223*, Ser. A., 289 (1923).
14. Uhl, V. W., *Chem. Eng. Prog. S. S.*, *51*, 17 (1955).
15. Uhl, V. W., *Official Digest, Federation of Paint and Varnish Production Clubs*, *310*, 885 (1960).
16. Uhl, V. W., Ph. D. thesis, Lehigh Univ. (1952).

Methods of management

Three important companies in our field of interest have lately carried on researches into their own methods of management and we are privileged to summarize some of their findings here. This subject was discussed by representatives of these companies and the brief condensations following mention rather than discuss the points made, but they supply indices to guide those interested in pursuing the subject.

—Editor

How do people grow in a business organization?

MOORHEAD WRIGHT

THE DECISIONS OF American business managers are going to have great effect upon the course of the world. Ours is a business-oriented society. Businessmen have real leadership in this country. And this country has real leadership in the world.

Throughout history, the human being has advanced very little or not at all, while the scientific and physical things he has in his hands have grown out of all proportion. It is a terrible commonplace to observe that man now has the power to destroy himself and his world. We must find the way to greater wisdom in handling our present power for good or evil, or we will leave a terrible mess for our children to live in.

The quality of our decisions—particularly those in regard to people—*must* be really good and really high.

Much work in management development—in our company as well as in others—has been a sort of procedural approach based on printed forms and systems and, it must be admitted, based on information which is not too deep or thought-through.

In October of 1951, as a part of his program for the decentralization of the General Electric Company, Ralph J. Cordiner, president of the company, established a research project with an assignment to "study the basic factors involved in the development of people and recommend a course of action for the company."

One of the principal findings of our research project was that we need much more research, before we even begin to know an appreciable part of the many factors involved. Great gaps in our knowledge may not be filled for generations. Our research is continuing and we are working closely with other businesses, universities, and others. We hope that in time we will have a body of solid knowledge about the development of people, which will enable all our managers to do, more effectively, this development task which is both their high obligation and great opportunity.

Moorhead Wright has been with General Electric since he received his degree in electrical engineering in 1927. Currently, he is manager-operations at the company's management research and development institute in Ossining, New York. Wright has lectured at both the Harvard Divinity School and Harvard Business School, on the Moral and Social Responsibilities of the Business Man. He has also lectured in the advanced management courses of AMA and the Society for the Advancement of Management.

From the research came a mass of data—some of it very sound, strong, and relevant—much of it unimportant. From the good data we have derived ten generalizations which appear to be useful guides in approaching the development process. They can in no sense be viewed as "eternal verities," because they have not been adequately proven in use. There is, however, enough evidence, both from research and practice, to establish these principles as useful guides. They are presented here primarily to encourage other companies to embark on research in this area—about which so little is known—in order to add to the field of hard knowledge available to everyone in industry faced with the necessity of doing this critical work of helping people develop.

The principles are simple and even obvious. In reading them one may be inclined to say, "Of course, of course—everybody knows that." However, study and observation indicate that these "obvious" principles are more often violated and ignored, than observed and honored. Here they are:

1. The development process is a highly individual matter.

2. Every man's development in business is SELF-development.
3. The development of people cannot be based upon any set of ideal or specified "personality characteristics or traits."
4. A man's development is 90% the result of his experience in his day-to-day work.
5. Opportunity for development must be universal.
6. Primary emphasis must be on development in the present assignment, rather than emphasis on a promotional ladder.
7. Managing is a separate and distinct kind of work which is emerging as another profession.
8. Decentralization of decision-making is a prime instrument of development.
9. The incumbent line manager at all levels is responsible for the development of people who work under his direction.
10. Moral and spiritual values are basic in the development process.

Meeting tomorrow's needs

R. Carter Wellford

Very simply, management development is the continuing growth of the entire management group to meet the needs of tomorrow. It must not only provide for the continuing growth of present managers in their present positions, it also has to produce men capable and ready to move into each level of responsibility including the highest echelons.

Whereas this discussion is primarily concerned with the development of managers, to have a successful program one must also place high emphasis on the development of and opportunity for men as individual contributors. In a modern chemical company the growth of professional competence in chemistry, all branches of engineering, finance, sales, etc., is vital to our continuing success and progress. Not every man has the desire nor feels himself qualified to make his contribution through supervising others, but his value to the organization can be of equal or, often, greater consequence.

Among the many factors which influence the growth of management people in the DuPont Company, are three broad philosophies. First is our strong belief in a decentralized organization structure. Since 1921 our business has been divided among industrial departments, each with a General Manager who has authority essentially equivalent to that exercised by the President of an independent subsidiary.

Second is our principle of promotion from within. This principle has operated from the inception of the Company in 1802. Only in rare instances in recent years have we employed experienced personnel into key positions, and most of these have been in professional assignments such as advertising, public relations, legal, medical, and specialized research functions. To maintain this principle we must continue to bring able young men into the lower levels of our professional and supervisory ranks. These men must develop and move into more responsible positions sufficiently rapidly to meet future needs.

Third, our whole approach to management development is more a philosophy than a program per se. Our objective is to utilize the skills of each individual to the maximum capacity he is able to fulfill and willing to undertake. We do not feel that we have any "magic formula." We do not feel that there is any one specific course of action which, if followed to the letter, will ensure the adequate growth of management personnel. The continued growth of a man is a highly personal thing which is a product of his inner drive to develop himself, but which can be materially aided by a blend of:

1. Coaching and experience on the job.
2. Adequate appraisal of his potentiality and discussion of his performance.
3. Job rotation—cross-fertilization.
4. Off-the-job education both inside and outside the company.
5. Helping him to attain a broad business understanding.

R. C. Wellford is assistant to departmental management in Du Pont's Employee Relations Department. He joined the company in 1931, and has held many positions since, including foreman, shift supervisor, and personnel supervisor. Wellford was personnel manager of the Film Department from its organization in 1950 until he took his present assignment. A graduate of VMI, he studied law at the University of Virginia.

During the past year we made a rather complete study of management development both inside and outside the company. In the course of this study, we talked to some 200 members of DuPont management to obtain their ideas as to what we might do to further stimulate the growth of management people. Those five areas in a sense are a summary of their opinion as to what has worked best in the past and what, they believe, will work best in the future.

You may wonder whether we are always satisfied with the people available for higher jobs at the time required. We would have to admit that sometimes we are not and are forced to take larger gambles than we prefer. The causes usually arise from lack of planning or lack of courage in facing distasteful moves sufficiently early.

You may also wonder whether we lose good people to outside competitors. We do. At the lower levels, we believe, fewer of our good young men resign than is the case in industry generally. However, our losses are greater than we like. Among promotable men with more experience, however, resignation is a relatively rare event. Of some 1700 employees whose names have appeared on our promotability forecasts during the past four-year period, we have lost nine by resignation.

In summary, we hope we can say to the young man joining us today who has the ambition to be a high-ranking member of management or with the ambition to be an outstanding individual contributor, "Welcome aboard, we will put you to work quickly; we

will train you thoroughly; we will appraise your performance and potentiality systematically. If you demonstrate the aptitude and desire, we will give you the opportunity to try a variety of jobs. You will work for a variety of people. Some will be men who will continue up the ladder, just as we hope you can. Others will be men who have approached their zenith, but you can learn a lot from them as some of them are the best trainers. You will not get lost if you have the character and ability to really contribute. There will be times when you become discouraged, but you can have a lot of fun and a rewarding experience if you have the stuff."

Finally, may we emphasize that management development is far from static in our company. Don't be surprised if someone from Dupont may describe very different procedures at some future meeting. We doubt that he will describe many basic changes in principles, but we are sure that our constant reappraisal of methods will bring changes in their implementation.

Enlightened salary administration

RICHARD B. BLOMFIELD

AN ENLIGHTENED SALARY ADMINISTRATION PROGRAM DOES FOUR THINGS:

1. It adequately and fairly compensates the personnel within an organization.
2. It encourages individual growth and development.
3. It is competitive in the market place.
4. It provides freedom of action for managers to administer salaries at their levels.

By fixing as much of the responsibility as possible at the point of contact between the employee and his supervisor, modern salary administration tends to eliminate "passing the buck." It makes many contributions to a company but in the long run its most important contribution is the creation of employee morale.

Many of the "gimmicks" used in salary administration today are often more of a hindrance than a help. The first of *two important problem areas* in this connection deals with the *indiscriminate use of maturity curves.* Maturity curves, as you know, are the ones on which dollars are plotted vertically and age and years-since-basic-degree are plotted horizontally. There is nothing new in this concept. They are patterned after the European system of "wage for age." While these curves are useful tools to be used as guides to sound salary administration, too often managers use them as a crutch. When they do this they sometimes get bear-trapped into using the statistics as controlling factors.

When used as auxiliary guides these curves are useful. They are most revealing during an employee's first ten years on the job. This is the period when the top-flight employee emerges, and every effort should be made to locate him and recognize him salary-wise. Age in many cases is an indicator of experience, and worth-while experience or seasoning is a key factor in most positions.

However, maintenance of individual levels of compensation should be based primarily on the recognition of contribution and performance. This means less reliance on system, and more reliance on judgment. This approach is far superior to that based on length of service, age, or type of degree.

The second problem areas I want to emphasize is the *reluctance* of some companies to *delegate authority* in the area of compensation. A plant manager, responsible for several millions of dollars worth of product, may not be allowed to grant an increase to any employee earning over $6,000 per year. In one breath these companies exhort the manager to manage, and at the same time they say, "Hold on, Buster, we'll make the decisions in this area."

This negative approach is one that does not meet the test of good morale. The belief of this manager in himself is certainly not strengthened. Even worse, being human, he might ask a subordinate to cut down on the amount of a well-thought-out and merited increase being proposed so *he* can approve it.

Under a "guidance" approach, top management would grant the plant manager salary approval authority commensurate with his position. Any necessary control could be exercised through the medium of an over-all budget.

R. B. Blomfield is personnel manager for Mack Trucks, Inc. He attended Harvard Law School and has an MA in personnel administration from Columbia University. Before joining Mack in 1959, he was for four years manager, salary administration, for Union Carbide. Blomfield was also assistant to the general manager of industrial relations for the Linde Company Division of Carbide. An active AMA seminar leader, he is a director and past president of the New York Chapter, American Society of Training Directors.

While use of a guidance approach will help to alleviate many problems, another very important area requires management's constant attention. This is the problem of *how to motivate* the administrative, professional, sales, or supervisory employee who is earning a good salary and doing "enough to get by." His motivation is a tremendous challenge.

Basically we must see that every employee receives the kind of rewards in dignity, appreciation, and compensation that will take into account the economic facts of life and at the same time give him a satisfying and creative career.

Good company morale is the sum total of the healthy morale of a group of individuals. This in turn results in employees wanting to identify themselves with the company. In companies that achieve a high degree of identification, competent men are convinced that almost anything is possible in the way of a career. The opposite is true in companies with poor morale. To put it another way, successful companies provide a proper environment.

In salary administration the first step to be taken under an enlightened program is job analysis based upon well-written job descriptions. But an important distinction must be made; descriptions for management and professional jobs require *individual* study.

A repetitive listing of vague generalities will not suffice. Neither will a shortsighted approach which takes into consideration the job without the man.

Just as it is impossible to separate the man from the job in describing his position, it is also impossible not to have him influence an evaluation. When a job such as traffic manager

or research director is under consideration, the incumbent must be considered. The way he organizes his function will be different from both his predecessor's and his successor's. By considering the individual I am referring to the way in which he shapes his job. This should not be confused with his performance.

Individual motivation can also be encouraged by making use of the dual "Manager-Specialist Expert" ladder, or what I prefer to call the "motivation Y." This approach is usually associated with research laboratories. Entering professionals are hired at the bottom of the "Y" at the lower salary ranges. After a few years of experience some are chosen as Group Leaders and others become Research Scientists. At this point the individual who becomes a Group Leader goes into the entry job on the Administration arm of the "Y" and may then progress up this arm to Director of Research. The fledgling Research Scientist can progress up the professional arm to a job of Senior Research Consultant which should be at a level close to that of Director of Research. This enables a company to recognize that a man can make fully as great a contribution in the role of professional specialist as he can in the role of Administrative Manager.

In many industries today more and more companies are requiring the services of well-trained specialists in auxiliary departments. This arm of the ladder should also be open to them. Such a move could open new avenues to many employees who are now stymied in their present assignments.

Up to this point we have been talking about straight salary plans. A straight salary has certain advantages. From the employee's point of view it is a regular source of income that can be relied upon. It is the basis of his personal financial plans. However, because of progressive income taxes, it is not very effective for developing an estate, providing for retirement, or taking care of an executive's family if he dies or is disabled. Salaries are also a relatively inflexible charge against earnings that cannot be readily reduced by a company when profits decline.

These three articles are the outgrowth of a symposium prepared by John S. Wilson, Heidrick and Struggles, Inc., Chicago. His activity included editing and condensation which resulted in this excellent presentation.

Opportunity and incentive or hope of reward must be listed among the forces that have helped to produce the American business system. Profit is the reward and measure of success in this system. Supplemental compensation programs are devices used by many companies to increase profits.

By supplemental compensation programs, we mean those that include some form of stock purchase, profit sharing, bonus, restricted stock option, or incentive plan.

How do these programs increase profits? Supplemental compensation does this by:

1. Making available a maximum net return after taxes for the executive at a minimum cost to the company.
2. Tying in executive compensation more closely to profits and to individual executive performance than is possible in straight salary programs.
3. Treating the executive as a partner in the company.
4. Bringing more flexibility into the compensation program so that expenses can be reduced more easily when profits decline.

No compensation plan can replace good management. Company officials cannot and ought not to expect a compensation plan to be a substitute for wise leadership—leadership that combines financial rewards and the intangible satisfactions discussed earlier.

Wise leadership brings to mind what one company president had to say about budgets. His remark has a bearing on enlightened salary adminstration. Mr. D. L. Yunich, President of L. Bamberger and Company, had this to say: "A budget represents yesterday's planning. If reasons are compelling enough, the budget can be . . . and should be . . . changed. The budget is not a straight jacket intended to freeze all thought and action."

A salary program is going to be no better or no worse than the over-all philosophy under which a company operates. These philosophies have to be those that permit a company to keep the faith not only with its employees but with stockholders and customers as well.

Water pollution control

THIS REVIEW IS THE FIRST of a series of biennial surveys of recent developments in the field of water pollution control which are of particular interest to chemical engineers. It is the hope of the Pollution Control Engineering Committee that these reviews will promote the adaptation of chemical engineering principles in the field of industrial waste treatment and will stimulate the interest of the profession in this field.

The role which the chemical engineer can profitably play in pollution control was discussed in an article by

continued on page 82

This review of the chemical engineering aspects of water pollution control was prepared by a subcommittee of the Institute's Pollution Control Engineering Committee. Members of the subcommittee were Henry C. Bramer (chairman), J. F. Conlon, D. A. Dahlstrom, W. W. Eckenfelder, C. Fred Gurnham, R. J. Keating, and G. H. Teletzke.

One of the objectives of the Pollution Control Engineering Committee is to prepare biennial reports on water pollution and air pollution, in alternate years. Comments on this review and suggestions for future reviews are solicited.

W. L. Faith, Chairman, PCE Committee

Weston in *Chemical Engineering Progress* in 1957 (*1*); it was shown that the chemical engineer has a unique opportunity to prevent or to reduce pollution at all stages of industrial operations from process development to production. The way in which the training of the chemical engineer can be applied to waste treatment problems was the subject of a paper by Gurnham in 1951 (*2*).

Although there are many useful books on industrial waste treatment, Gurnham's book (*3*) is the single one written in terms of the chemical engineering unit operations concept. This book contains excellent references to sources of information in specific problem areas.

The objective of most industrial waste treatment is compliance with the requirements of state or other regulatory agencies. To do the most effective job, the pollution control engineer should keep abreast of the latest developments in the legal and administrative areas. The U. S. Public Health Service and the Ohio River Valley Water Sanitation Commission have effectively utilized the services of advisory groups from industries concerned with pollution control in recent years (*4, 5*) and these committees afford industry representatives excellent opportunities to contribute to the formation of sound regulations. A paper by Hoak (*6*) presents a general discussion of the determinants of sound legislative action; the Council of State Governments has outlined the organization of water resources administration in the various states (*7*). A recent publication by the Manufacturing Chemists Association summarizes the water pollution laws of the states and territories and offers comments on the policies of the several control agencies (*8*).

In-plant control

The chemical engineer can probably make his greatest contribution to water pollution control by preventing or minimizing the discharge of wastes through in-plant measures. Such measures include water conservation, recovery, and re-use; good housekeeping practices; process changes; material salvage and by-product recovery; collection, segregation and equalization of waste streams and operator education. In-plant pollution control was the subject of a symposium during the 1958 A.I.Ch.E. Annual Meeting in Cincinnati (*9*); three papers presented at this symposium have been published (*10, 11, 12*).

The cost of pollution abatement measures can be substantially reduced through water conservation practices; practical methods of accomplishing this objective in the metal finishing, steel and canning industries have been published in recent years (*13, 14, 15*). Recovery and re-use of process water can be practiced to reduce the load of pollutional materials discharged to a stream and provide a source of water in cases of limited supply. The methodology of recovery and re-use has been given for many types of industries in recent publications (*16, 17, 18, 19*). An excellent example of the elimination of pollution and the solution of a water supply problem by a closed-system design is given in a paper by Pettit (*20*). Another solution to water supply problems is the industrial utilization of treated municipal sewage (*21*); this practice is receiving more and more attention as many industries in water-short areas report satisfactory results.

Not all pollution abatement measures are complex or costly undertakings. Good housekeeping practices, for example, can very often result in substantial reductions of wastes. Unfortunately such measures are not often published, probably because they appear to be so obvious and simple once accomplished. Three publications concerning good housekeeping practice illustrate the type of information which could profitably appear more often in the literature (*22, 23, 24*).

Process changes which result in the elimination or reduction of wastes often reduce over-all costs substantially and represent an area in which the chemical engineer can be of maximum service in pollution control. Published material on this phase of in-plant control is also sparse and is especially to be desired in the chemical engineering literature. Two good examples of process changes for pollution control are given by Masselli and Burford (*25*) and by Wilcoxson (*26*).

Material salvage and by-product recovery have long been regarded as the most desirable solutions to wastes problems, and have received wide attention, especially in the popular literature. Although the actual examples of profits realized from wastes are limited, this approach does frequently offer a means to at least offset a portion of waste treatment costs. Examples of material salvage and by-product recovery with greater or lesser degrees of profitability have recently been published (*27, 28, 29, 30, 31*).

The collection, segregation, and equalization of waste streams can reduce both treatment costs and the effects of a given total load of pollutional material on a stream. Such in-plant measures are most effective in reducing costs when considered in original plant designs, but often offer alternatives to extensive treatment in operating plants. Watson (*32*) has discussed such measures in the metal-finishing industry and Frame (*33*) shows how these factors were considered in the design of an oil refinery. A publication by the Ohio River Valley Water Sanitation Commission is a valuable guide for use in making the surveys necessary for effective consolidation of waste streams (*34*).

Air view of three huge guard basins, with an API gravity separator, which insure against oil reaching the Delaware river. The guard basins use baffles, slow velocity, and skimming to deliver oily water to the separator.

The best waste treatment facilities are effective only insofar as they are operated properly. The pollution control engineer should interest himself in the training of competent plant operators for his waste treatment processes and in the education of all plant personnel in methods by which pollution can be reduced through proper

operation procedures. Many schools and state health departments offer short courses for plant operators and many companies and industry groups have found motion pictures to be effective for in-plant use as well as for the information of the general public. Little has appeared in the literature on this subject.

Waste treatment processes

In considering the methods by which a given waste may be treated, the pollution control engineer may refer to the literature peculiar to the industry involved or he may seek examples of particular types of treatment which may be adapted to his problem. The latter approach is typical of the unit operation-unit process concept in chemical engineering. Excellent reviews are available which are organized on an industrial classification basis (*35*); it is an objective of the present article to provide a review based upon the unit operation-unit process classification.

Liquid-solids separation operations used most frequently in waste treatment are sedimentation and flotation. Sedimentation of certain industrial wastes presents special problems due to the relatively high flows involved and the relatively low concentrations of suspended matter to be removed; the treatment of blast furnace gas-washer water is an example (*36*). The development of an empiricial design equation for sedimentation equipment in such applications has recently been reported (*37*). Flotation has been successfully used in treating coal washery effluents, oil refinery wastes, and other industrial wastes (*38, 39, 40, 41*). Miniature hydroclones present a new and interesting possibility for liquid-solid separation and may prove to be advantageous especially where space is limited (*42*).

Filtration is usually used in waste treatment practice in combination with other operations; seldom is filtration the complete treatment for a waste. Rotary vacuum filters of the various types are most often used. Pressure filtration has few applications in this field due to the low value of most recovered solids and the relatively large volumes to be handled. Developments of interest in the field of filtration include those concerned with rotary vacuum filters, precoat filters, disk filters, and the special problems in sludge filtration (*43, 44, 45, 46, 47*).

Heat transfer operations and combustion find wide application in industrial waste treatment and disposal. Evaporation is used in the concentration of radioactive wastes prior to underground or other disposal (*48*) and in treatment processes which involve precipitation of salts from spent solutions such as from acid pickling (*49*). Submerged combustion has found increased applications since burners have been greatly improved (*50*). The incineration of flammable wastes has become an important method of disposal where recovery cannot be justified (*51, 52*) and the Zimmerman "wet combustion" process has attracted much attention (*53*).

Mass transfer operations are being increasingly used in waste treatment. Ion exchange has many general applications (*54*) and offers possibilities for use in treating radioactive wastes (*55*). Adsorption has been used in treating tank car wastes (*56*) and in the recovery of dyes from waste streams (*57*). Liquid-liquid extraction has many possibilities in waste treatment (*58*) and the centrifugal extractor has increased the usefulness of this operation (*59*). An article by Heller, *et al.* (*60*) presents a good comparison of steam stripping and solvent extraction processes for phenol recovery from wastes.

Chemical treatment

Oxidation and reduction reactions are applicable to many industrial waste treatment problems in destroying pollutional substances in waste streams, in chemically altering toxic substances to render them innocuous, or in one phase of multistep treatment processes, and in partial oxidation for the purpose of reducing the oxygen-consuming power of wastes. Sulfur dioxide can be used to reduce chromium (*61*) and the chemical oxidation of phenol wastes has been studied (*62, 63*). Such treatment is effective in color removal from azo dye wastes (*64*). The theory and design of mixers for wastes aeration is discussed in a paper by Oldshue (*65*) and controlled oxidation is the basis of a lime neutralization process for waste pickle liquor which results in substantially reduced sludge volumes (*66*).

General chemical reactions including neutralization and replacement reactions are the basis of many waste treatment processes. The Ruthner process for regeneration of spent pickling solutions has attracted wide attention, although its economics are not particularly attractive due to high capital costs (*67*). The process is based upon the conversion of sulfates to chlorides with gaseous HCl and subsequent recovery of the HCl by roasting. Carbonate precipitation, neutralization, and other chemical reaction-based processes are discussed in three articles of interest (*68, 69, 70*). The reduction in volume of radioactive wastes by carrier precipitation presents a possible method for treatment of such wastes (*71*); the precipitated material is disposed of by burial or other means.

Biological treatment

The training and experience of most chemical engineers is such that biological treatment methods are usually unfamiliar. It should be recognized, however, that such methods are often the most satisfactory alternatives for many types of wastes, particularly organic wastes. Biological treatment methods are often applicable to high volume-low pollutant concentration effluents and are characteristically high capital cost installations with the advantage of relatively low operating costs. The various aspects of biological treatment have been well summarized in several recent publications (*72, 73, 74, 75, 76, 77*).

Aerobic biological treatment processes include trickling filtration, activated sludge, and oxidation ponds. Applications of aerobic processes in treating organic (*78, 79*), chemical and pharmaceutical wastes (*80, 81*), paper mill wastes (*82*), dairy wastes (*83*), and cannery wastes (*84*) are illustrative of the usefulness of such methods. Design factors for anaerobic biological treatment plants are given in an article by Buswell (*85*) and an example of this type of process is given for pharmaceutical wastes in a paper by Hurwitz, *et al.* (*86*). A good example of the ways in which engineers became involved in the biological and radiological problems of waste disposal is found in a University of Texas report (*87*).

This review has necessarily been brief due to space limitations and the fact that a considerable period of time is covered by the survey. The lack of published material, particularly concerning in-plant pollution abatement measures, indicates the need for more of this type of information in the chemical engineering literature. It is hoped that the role of the chemical engineer in pollution control has been shown and that publication of the type of material indicated will be stimulated.

LITERATURE CITED

1. Weston, Roy F., "The Role of the Chemical Engineer in Industrial Pollution Control", *Chem. Eng. Prog.*, 53, 365-6 (1957).
2. Gurnham, C. Fred, "Chemical Engineering Aspects of Industrial Waste Control," *Sew. and Ind. Wastes*, 23, 82-8 (1951).

3. GURNHAM, C. FRED, *Principles of Industrial Waste Treatment*, John Wiley and Sons, Inc., New York (1955).

4. U. S. PUBLIC HEALTH SERVICE, *Proceedings of the National Technical Task Committee on Industrial Wastes*, Annual.

5. OHIO RIVER VALLEY WATER SANITATION COMM., *Annual Reports*.

6. HOAK, RICHARD D., "Societal Aspects of Pollution Control," *AMA Archives of Industrial Health*, 17, 446-452 (1958).

7. COUNCIL OF STATE GOVERNMENTS, *State Administration of Water Resources*, Chicago (1957).

8. MANUFACTURING CHEMISTS ASSN., *Manual W-5, Compendium of Water Pollution Laws*, Washington, D. C. (1959).

9. GURNHAM, C. F., "In-Plant Pollution Control," *Chem. Eng. Prog.*, 55, 37 (Mar. 1959).

10. BRADY, S. O., "In-Plant Pollution Control, in Practice, I. Petroleum Industry," *Chem. Eng. Prog.*, 55, 45 (Mar. 1959).

11. BIALKOWSKY, H. W. and J. C. BROWN, "In-Plant Pollution Control in Practice. II. Pulp and Paper Industry," *Chem. Eng. Prog.*, 55, 54 (April, 1959).

12. WALKER, C. A. and J. A. TALLMADGE, "Metal Finishing Waste Reduction," *Chem. Eng. Prog.*, 55, 73 (May, 1959).

13. PINNER, W. L., "Practical Methods for In-Plant Reduction of Metal Finishing Wastes," *Sew. and Ind. Wastes*, 24, 1432-5 (1952).

14. HOWELL, G. A., "Water Conservation in Steel Mills," *Sew. and Ind. Wastes*, 24, 1368-71 (1952).

15. MERCER, W. A., W. W. ROSE, C. E. BUTLER and M. M. AFFLEMAN, "More Effective Product Washing With Less Water," *Proceedings of Technical Sessions, 31st Annual Convention, National Canners Assoc.* (1958).

16. LOVE, S. K., et al., "Symposium: Re-Use of Water by Industry," *Ind. Eng. Chem.*, 48, 2145-68 (1956).

17. SESSLER, R. E., "Waste Water Use in a Soap and Edible-Oil Plant," *Sew. and Ind. Wastes*, 27, 1178-82 (1955).

18. LUDDEN, JOHN, JR. and J. F. VOGLER, "Water Conservation in a Chemical Plant," *Sew. and Ind. Wastes*, 24, 1377-81 (1952).

19. SIMONSEN, R. W., "How Four Oil Refineries Use Water," *Sew. and Ind. Wastes*, 24, 1372-7 (1952).

20. PETTIT, G. A., "Treatment and Re-Use of Mill Scale Wastes," *Iron and Steel Engr.*, 34, 144-51 (1957).

21. CONNELL, C. H., "Utilization of Waste Waters," *Ind. Wastes*, 3, 5, D-32 (1958).

22. BARNES, G. E. and L. W. WEINBERGER, "Internal Housekeeping Cuts Wastes Treatment at Pickle Packing Plant," *Wastes Eng.*, 29, 1, 18-21 (1958).

23. OHIO RIVER VALLEY WATER SANITATION COMM., *Plating-Room Controls for Pollution Abatement*, (1951).

24. POOLE, B. A. et al., "Control of Accidental Discharge of Cyanide Solutions," *Sew. and Ind. Wastes*, 26, 1382-7 (1954).

25. MASSELLI, J. W. and M. G. BURFORD, "Pollution Reduction in Cotton Finishing Wastes Through Process Chemical Changes," *Sew. and Ind. Wastes*, 26, 1109-16 (1954).

26. WILCOXSON, L. S., "Development of the Magnesia-Base Pulping Process," *Proc. 6th Ind. Wastes Conf.*, Purdue Univ., 51 (1951).

27. HARRIS, T. R., "Disposal of Refinery Waste Sulfuric Acid," *Ind. Eng. Chem.*, 50, 81A (Dec. 1958).

28. OTHMER, D. F., "Acetic Acid Recovery Methods," *Chem. Eng. Prog.*, 54, 48-52 (July, 1958).

29. WHITMORE, L. M., JR. and A. J. WILEY, "Chemical By-Products from Spent Sulfite Liquors," *Chem. Eng. Prog.*, 54, 80-a (Dec., 1958).

30. OHIO RIVER VALLEY WATER SANITATION COMM., *Dust Recovery Practice at Blast Furnaces*, Cincinnati (1958).

31. HAURI, C. F., "Reduction of Plating Waste Losses by Reclaim Tanks," *Sew. and Ind. Wastes*, 25, 586-90 (1953)

32. WATSON, K. S., "Treatment of Complex Metal-Finishing Wastes," *Sew. and Ind. Wastes*, 26, 182-96 (1954).

33. FRAME, JOHN, "From Refinery Wastes to Pure Water of the Cities Service Trafalgar Refinery," *Proc. of the 8th Ontario Ind. Waste Conf.*, Toronto (1959).

34. OHIO RIVER VALLEY WATER SANITATION COMM., *Planning and Making Industrial Waste Surveys*, Cincinnati (1952).

35. HEUKELEKIAN, H., et al. "1959 Literature Review, Part II," *Sew. and Ind. Wastes*, 31, 615 (1959).

36. HENDERSON, ANGUS D. and J. J. BAFFA, "Waste Disposal at a Steel Plant: Treatment of Flue Dust Waste," *Proc. Amer. Soc. Civil Eng.*, 80, Separate No. 494, (1954).

37. HOAK, R. D. and H. C. BRAMER, "Theory and Practice in Recovery of Flue Dust and Mill Scale," *Regional Technical Meetings, American Iron and Steel Institute*, 61, New York (1958).

38. EVESON, G. F., S. G. WARD, and F. WORTHINGTON, "Froth Flotation of Low-Rank Coal," *J. Inst. Fuel*, 30, 298 (1957).

39. BEEBE, A. H., "Soluble Oil Wastes Treatment by Pressure Flotation," *Sew. and Ind. Wastes*, 25, 1314-22 (1953).

40. ROHLICH, G. A., "Pilot Plant Studies of Air Flotation of Oil Refinery Waste Waters," *Proc. 8th Ind. Waste Conf.*, Purdue Univ., 368 (1953).

41. BAUM, R. A. and G. E. HURST, "Treatment of Municipal and Industrial Wastes by Flotation," *Proc. 8th Ind. Waste Conf.*, Purdue Univ., 10 (1953).

42. MATSCHKE, D. E. and D. A. DAHLSTROM, "Miniature Hydrocliones-Energy Requirements and Solid Elimination Efficiency," *Chem. Eng. Prog.*, 54, 60-64 (1958), 55, 79-82 (Dec., 1959).

43. SMALL, HAROLD M. and WALTER C. GRAULICK, "Precipitation and Filtration," *Plating* (August, 1956).

44. WIEST, GORDON J., "Current Problems with the Vacuum Filtration of Sludge," *Sew. and Ind. Wastes*, 29, 483-6 (1957).

45. SILVERBLATT, CHARLES E. and D. A. DAHLSTROM, "Continuous Disk Filters for Fine Coal," *Coal Age*, 60, 77 (1955).

46. CORNELL, E. D., C. F. CORNELL and R. C. EMMETT, "Recent Developments in Continuous Vacuum Filtration," *Proc. 11th Ind. Waste Conf.*, Purdue Univ., 405 (1956).

47. BELL, G. R. and F. B. HUTTO, JR., "New Concepts in the Analysis of Rotary Precoat Filter Operation," *Chem. Eng. Prog.*, 54, 69, (Dec., 1958), 55, 75, (Jan., 1959).

48. MCCULLOUGH, G. E., "Concentration of Radioactive Liquid Waste by Evaporation," *Ind. Eng. Chem.*, 43, 1505-9 (1951).

49. SLACK, F. H., "Processes and Plant for Spent Acid Reclamation," *Chem. Products (Brit.)*, 20, 467 and 507 (1957).

50. WEISMAN, WILLIAM I., "Application of Submerged Combustion in Industrial Waste Treatment," *Proc. 8th Ind. Wastes Conf.* Purdue Univ., 363 (1953).

51. GURNHAM, C. F., "Waste Solvent Incineration Successful at Upjohn Co.," *Ind. Wastes*, 2, 29 (1957).

52. GARRETT, J. T., "Multipurpose Incineration," *Industrial Wastes*, 2, 111 (1957).

53. JACKSON and BROWN, "Oxidation of Spent Semichemical Pulping Liquors by the Zimmerman Process," *Pulp and Paper*, 69 (Feb. 1958).

54. BUELTMAN, C. G., "Ion Exchange Treatment of Industrial Wastes," *Sew. and Ind. Wastes*, 29, 1018 (1957).

55. AYRIS, J. A., "Treatment of Radioactive Waste by Ion Exchange," *Ind. Eng. Chem.*, 43, 1526-31 (1951).

56. GUTZEIT, GREGOIRE and GLENN ENYART, "Tank Car Wastes Treated by Chemical Adsorption," *Wastes Eng.*, 23, 18-22 (1952).

57. THORNTON, H. A. and J. R. MOORE, "Adsorbents in Waste Water Treatment—Dye Adsorption and Recovery Studies," *Sew. and Ind. Wastes*, 23, 497-504 (1951).

58. LEWIS, C. J., "Possibilities for Liquid-Liquid Extraction in Industrial Waste Treatment," *Proc. 12th Ind. Waste Conf.*, Purdue Univ., 543 (1957).

59. PODBIELNIAK, W. J. and H. R. KAISER, "Dephenolizing with Centrifugal Extractors," *Blast Furnace and Steel Plant*, 44, 760 (1956).

60. HELLER, A. N., E. W. CLARKE and W. M. REITER, "Some Factors in the Selection of a Phenol Recovery Process," *Proc. of the 12th Ind. Waste Conf.*, Purdue Univ., 103 (1957).

61. CHAMBERLAIN, N. S. and R. V. DAY, "Technology of Chrome Reduction with Sulfur Dioxide," *Proc. 11th Ind. Waste Conf.*, Purdue Univ., 129 (1956).

62. OHIO RIVER VALLEY WATER SANITATION COMM., *Phenol Wastes — Treatment by Chemical Oxidation*, Cincinnati, (1951).

63. HALL, D. A., "Treatment of Coke Works Effluent with Ozone," *Gas World*, 52, 7-13 (1958).

64. NEMEROW, N. L. and W. L. WILSON, "Color Removal from Azo Dye Wastes," *Ind. Eng. Chem.*, 49, 77A (Dec. 1957).

65. OLDSHUE, J. Y., "Theory and Design of Mixers for Aeration of Wastes," *Proc. 10th Ind. Waste Conf.*, Purdue Univ., 391 (1955).

66. HEISE, L. W. and M. JOHNSON, "Disposal of Waste Pickle Liquor by Controlled Oxidation and Continuous Lime Treatment," *Proc. 9th Ind. Waste Conf.*, Purdue Univ., 381 (1954).

67. STRASSBURGER, J. H., "Evaluation of the Blaw Knox-Ruthner Pilot Plant Program," *Yearbook of the American Iron and Steel Institute*, (1958).

68. BROWN, H. S., et al., "Process Using Carbonate Precipitation," *U. S. Patent 2, 768, 871* (Oct. 3P, 1956).

69. OHIO RIVER VALLEY WATER SANITATION COMM., *Disposal of Spent Sulfate Pickling Solutions*, Cincinnati (1952).

70. HOAK, R. D., "Acid Iron Wastes Neutralization," *Sew. and Ind. Wastes*, 22, 212-21 (1950).

71. BURNS, R. E. and M. J. STEDWELL, "Volume Reduction of Radioactive Wastes by Carrier Precipitation," *Chem. Eng. Prog.*, 53, 93-F (1957).

72. SAWYER, C. N., J. D. FRAME and J. P. WELD, "Some Revised Concepts Concerning Biological Treatment," *Proc. 9th Ind. Waste Conf.*, Purdue Univ., 217 (1954).

73. MCCABE, J. and W. W. ECKENFELDER (Eds.,) *Biological Treatment of Sewage and Industrial Wastes*, Reinhold Pub. Corp., New York (1956).

74. WESTON, R. F. and W. W. ECKENFELDER, "Kinetics and Equilibria of Oxidative Treatment," *Sew. and Ind. Wastes*, 27, 802 (1955).

75. MCKINNEY, R., "Fundamental Biochemistry of Waste Disposal," *Sew. and Ind. Wastes*, 25, 1129 (1953).

76. ECKENFELDER, W. W., "Process Design of Aeration Systems for Biological Waste Treatment," *Chem. Eng. Prog.*, 52, 286 (1956).

77. ECKENFELDER, W. W. and T. L. MOORE, "Bio-Oxidation," *Chem. Eng.*, (Sept. 1955).

78. HATFIELD, R. "Biological Oxidation of Some Organic Compounds," *Ind. Eng. Chem.*, 49, 192 (1957).

79. ECKENFELDER, W. W., JR. and DONALD O'CONNOR, "Aerobic Biological Treatment of Organic Wastes," *Proc. 9th Ind. Waste Conf.*, Purdue Univ., 512 (1954).

80. TOMPKINS, L. B., "Two-Stage Filter Operation at the Upjohn Waste Treatment Plant," *Sew. and Ind. Wastes*, 29, 1161 (1957).

81. DRYDEN, F. E., P. A. BARRETT and J. C. KISSINGER, "Treatment of Fine Chemical Wastes by High-Rate Activated Sludge," *Proc. 10th Ind. Waste Conf.*

82. PORTER, C. C. and F. W. BISHOP, "Treatment of Paper Mill Wastes in Biochemical Oxidation Ponds," *Ind. Eng. Chem.*, 42, 102-6 (1950).

83. PORGES, N., L. JASEWICZ and S. R. HOOVER, "Aerobic Treatment of Dairy Wastes," *Applied Microbiology*, 1, 262 (1953).

84. ECKENFELDER, W. W. JR., and EDWARD R. GRICH, "Plant Scale Studies on the Biological Oxidation of Cannery Wastes," *Proc. 10th Ind. Waste Conf.*, Purdue Univ., 549 (1955).

85. BUSWELL, A. M., "Design and Loading Factors for Anaerobic Fermentation Plants," *Ind. Eng. Chem.*, 42, 605-7 (1950).

86. HURWITZ, E., K. H. EDMONDSON and S. L. CLARKE, "Pharmaceutical Waste Treatment," *Water and Sew. Works*, 99, 202-5 (1952).

87. GLOYNA, E. F., E. R. HERMANN and W. R. DRYNAN, "Oxidation Ponds—Waste Treatment Studies, Radioisotope Uptake and Algae Concentration," *Technical Report No. 2 to A. E. C.*, Univ. of Texas (1955).

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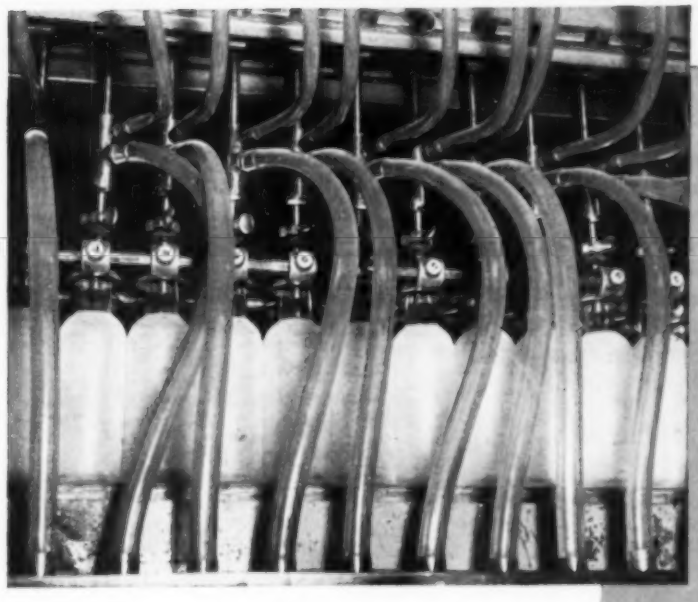

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CEP COMPUTER PROGRAM abstracts

The Machine Computation Committee of the A.I.Ch.E. is interested in receiving program abstracts. Once again the Committee wishes to emphasize the three rules for participation in the interchange program:

1) Abstracts submitted for publication must follow the form published in *CEP* (January, 1959) and in the *Guide*.

2) Abstracts must be sent to the Machine Computation Committee c/o A.I.Ch.E.

3) All questions relating to published abstracts must be sent to the Committee c/o A.I.Ch.E. in New York.

Nonlinear regression by criterion of least squares (034)

G. G. Bejarano, R. M. Baer, and L. Tornheim
Mathematical Services Group
California Research Corporation
Richmond, California

Description: This program determines the least squares fit for a large number of data points to an equation which is nonlinear in the parameters. The equation may also be nonlinear in the variables. Examples of such nonlinear equations are:

$$Y = \log\left[\frac{a_1 + X_1^{a_2}\,(100 - X_1)^{a_3}}{a_1 + X_2^{a_2}\,(100 - X_2)^{a_3}}\right]$$

$$Y = aX_1 + b_1 e^{b_2 X_2}$$

A modified Gaussian procedure is used. Back-solutions and statistical data are obtained as well as the constants (a_i, b_i) in the equation.

Computer: Datatron 205, 4000 words storage, card input and output, and floating point unit.

Program language: Datatron 205 machine code.

Running time: Depends on the form of the equation, the number of parameters and the number of observations. However, most solutions require from 10 to 30 minutes.

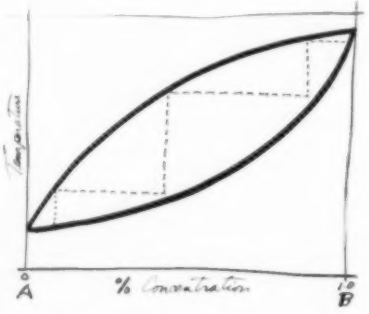
Comments: A subprogram must be written for each nonlinear equation and certain of its derivatives. The program has been used successfully on a wide variety of complex equations.

Availability: A manual will be prepared if sufficient interest develops.

Batch rectification of binary mixtures (042)

D. E. Danly[1] *and C. E. Huckaba*
Department of Chemical Engineering
University of Florida
Gainesville, Florida

Description: This program calculates the compositions of the distillate, plate-liquid, and residue as a function of the fraction of the charge distilled in batch rectification of a binary liquid mixture. Included in the program is a preliminary steady-state calculation to establish the initial condition of the column. Following this the program provides a numerical integration of



the set of differential heat and material balances describing the changes of composition with fraction distilled. The assumptions upon which the calculation procedure is based are: (1) negligible amount of vapor holdup in the column compared with the liquid holdup, (2) negligible heat losses from the column, (3) constant amount of holdup per plate, (4) uniform composition of liquid on each plate, and (5) longitudinal flow of material through the condenser system.

Computer: IBM 650 with 2000-word storage drum.

Program language: SOAP II.

Running time: One-half second per plate per incremental change in fraction distilled, $\Delta\phi$. To insure stability of the numerical integration, $\Delta\phi$ must be less than $\dfrac{H_n/S_o}{(R_n + 1)m + R_n}$

where H_n = amount of liquid holdup on plate n, S_o = amount of liquid in the kettle when $\phi = 0$, R_n = internal reflux ratio at plate n, and m = slope of the equilibrium line corresponding to the composition of liquid on plate n.

Comments: This program will handle calculations for columns having from one to forty actual trays.

Availability: A program manual can be made available for publication should sufficient interest develop.

Enthalpy lookup (043)

J. L. Niedzwiecki, R. E. Lieber, and P. A. Kehoe
Esso Research and Engineering Company
Design Engineering Division.
P. O. Box 209, Madison, New Jersey

Description: This program calculates the vapor and/or liquid enthalpies for mixtures of up to 75 components, including C_1-C_8 paraffins, C_2-C_4 olefins, C_6-C_8 aromatics, components characterized by normal boiling point, H_2, CO_2, CO, N_2, H_2O, and H_2S. In addition, enthalpy data for up to 5 unclassified components may be en-

continued on page 90

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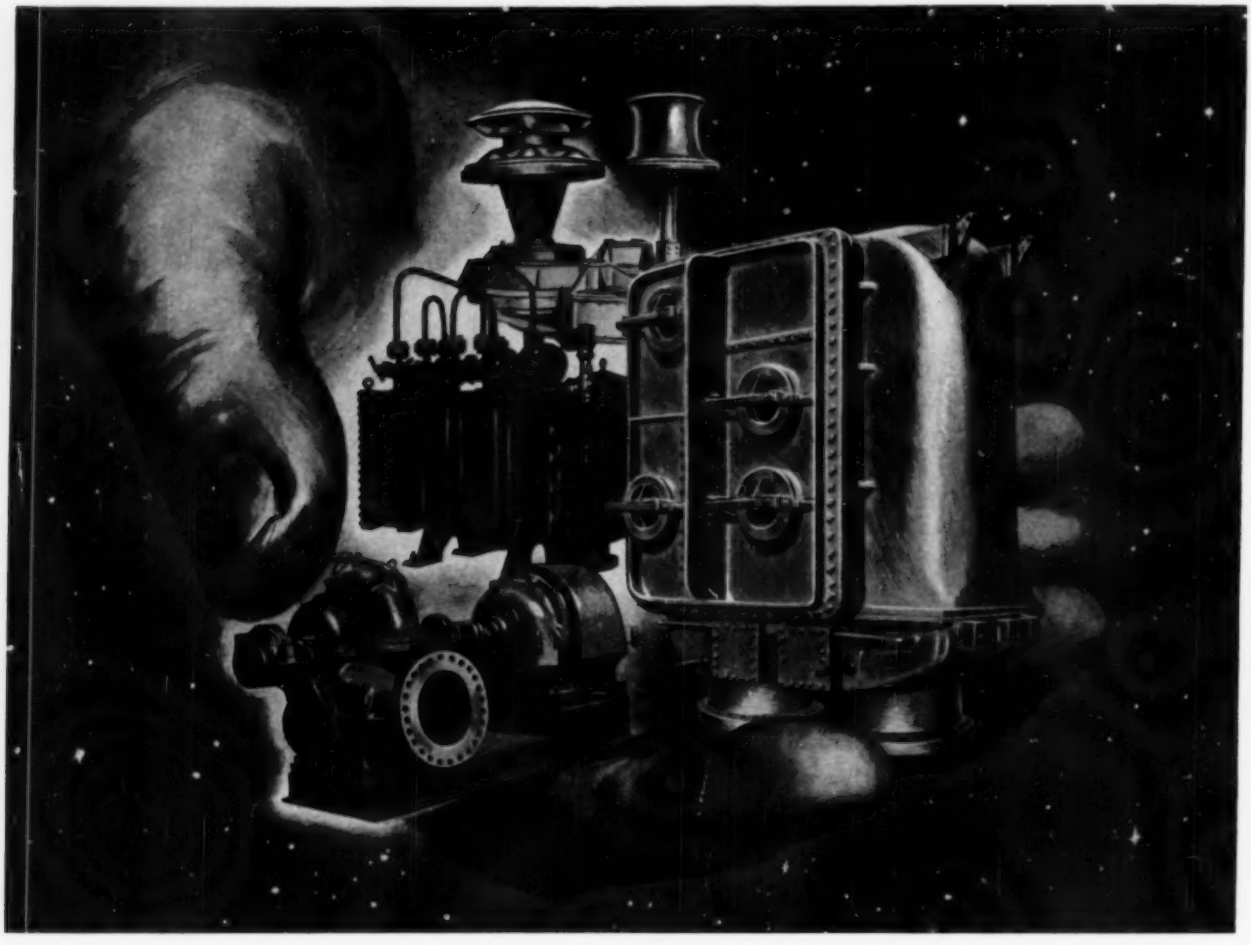

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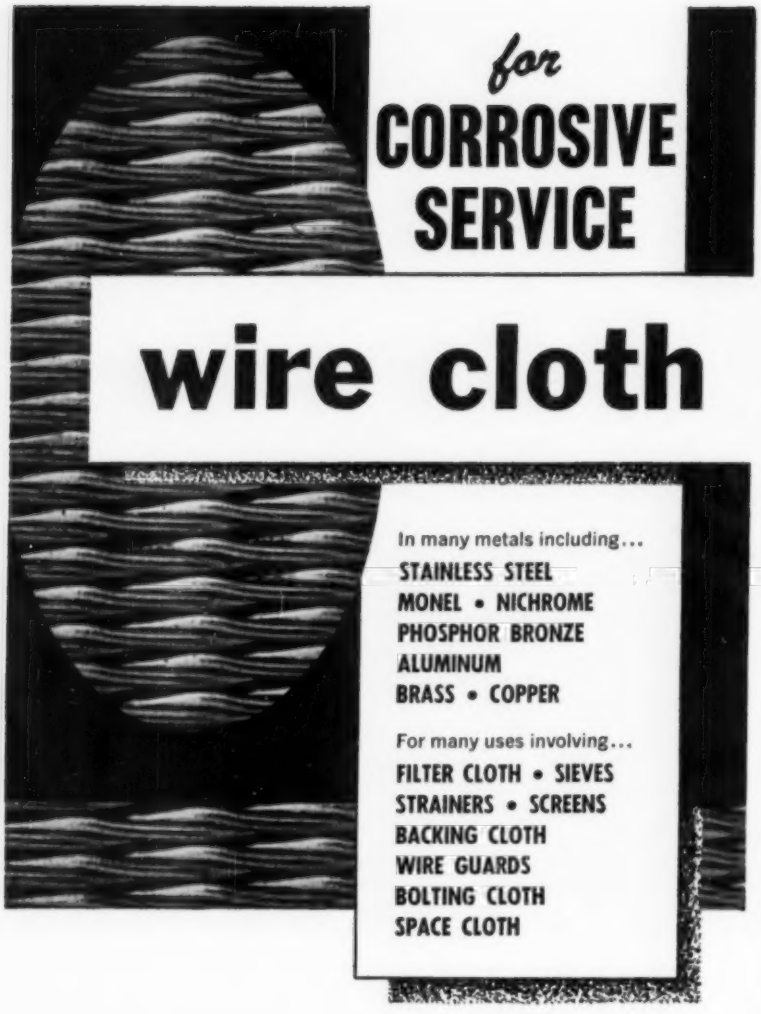

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Computer abstracts

from page 86

tered so that the program will handle mixtures which include a few components not covered by the incorporated correlations.

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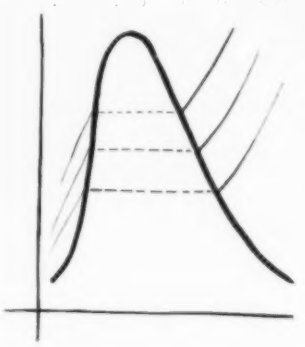

James R. West, "Thermodynamic Properties of Hydrogen Sulfide," *Chemical Engineering Progress*, April, 1948.

Computer: IBM 704; 8K core, 1 drum unit and 2 tapes; or 32K core, 2 tapes.

Program language: Fortran I.

Running time: 1¼ minutes to read in program from cards, 20 seconds to read data tape, then 9-15 seconds/combination of temperature and pressure.

Comments: The program has been provided with a data checking routine which will prevent machine stoppage resulting from pressure and temperature overranging of incorporated tabular information. Should any table be exceeded, the value at the point at which overranging occurred will be returned.

Availability: The manual on this program can be made available for publication should sufficient interest develop.

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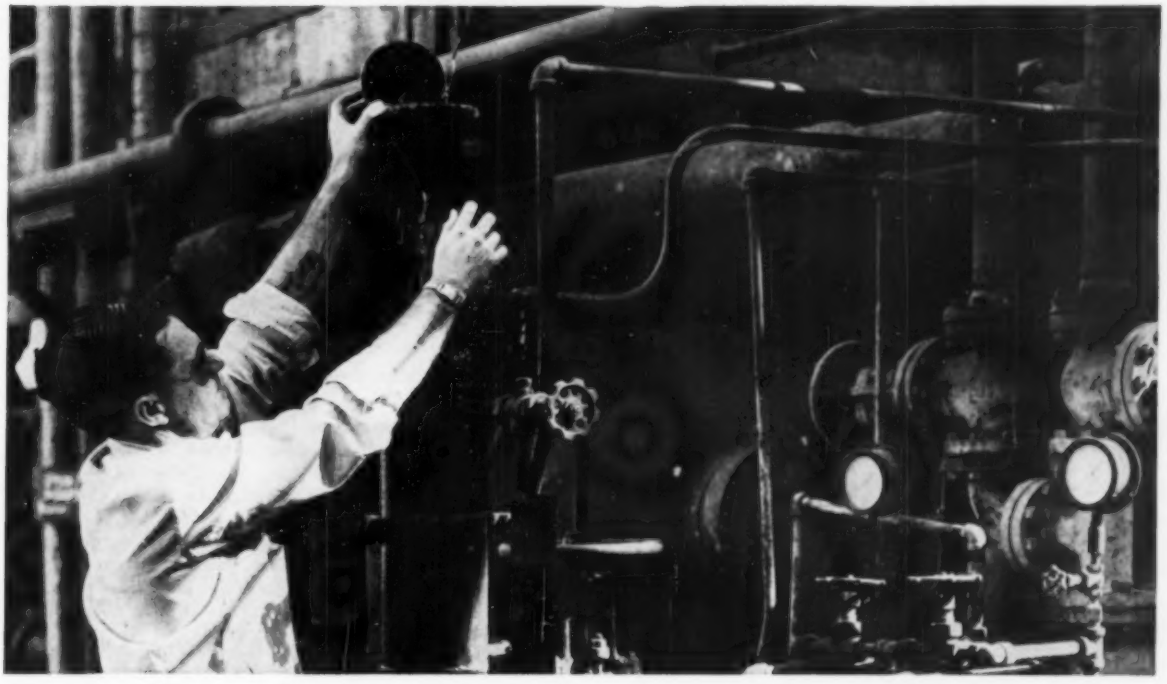

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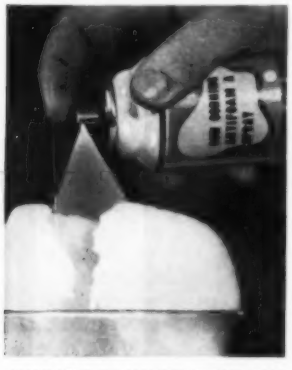

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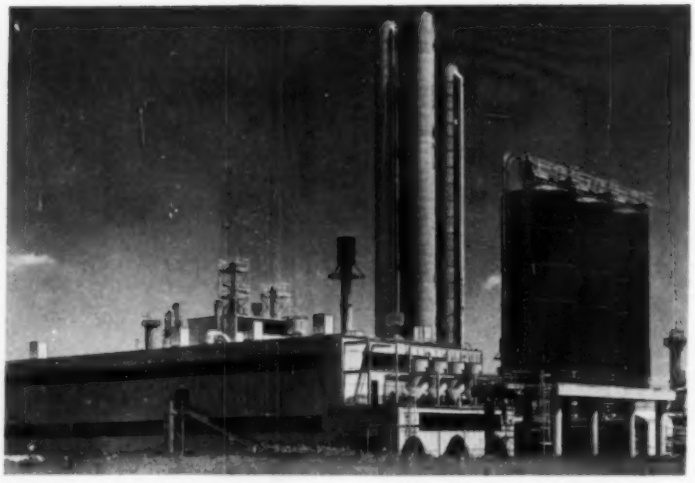
W. R. Grace buys petrochemical company

W. R. Grace has acquired controlling interest in Cosden Petroleum. Announcement coincides with new Cosden expansions in ortho-xylene, styrene.



Polystyrene unit at Cosden Petroleum's Big Spring, Texas, plant.

W. R. GRACE HAS DISCLOSED that it has received and accepted tenders of 1,580,000 shares of Cosden Petroleum common stock at $25.00 per share. This represents slightly over 51% of the outstanding shares, is Grace's first large-scale penetration into petrochemicals.

Almost simultaneously, Cosden has made public plans to increase facilities for styrene and ortho-xylene. Styrene production at Cosden's Big Spring, Texas, plant will be tripled—annual capacity will be 60 million pounds on completion of new process units late this year. Additional ethylbenzene for the new styrene unit will come from an Alkar unit using UOP's fixed-bed catalytic process for ethylbenzene from benzene and ethylene. Benzene will come from Cosden's existing BTX unit. Design, engineering, and construction for both of the new units has been awarded to Badger Manufacturing.

By early 1961, ortho-xylene production at Cosden will be "in excess of 70 million pounds per year." This represents approximately a doubling of existing capacity.

Warren to Gulf to Jefferson

Conroe, Texas, manufacturing facilities acquired by Jefferson Chemical, will be used for process development, intermediate-scale new products.

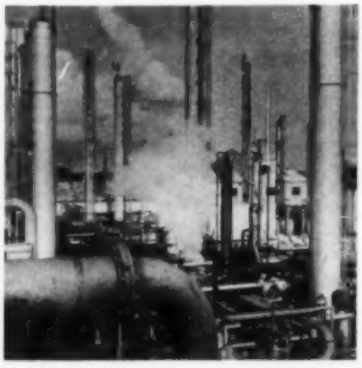
EXTENSIVE CHEMICAL manufacturing facilities at Conroe, Texas, (40 miles north of Houston) have been taken over by Jefferson Chemical from Gulf Oil who acquired them in 1957 from Warren Petroleum, original builders of the plant (1954).

Gulf used the plant for two years as a semi-commercial unit to determine the economic feasibility of a hydrocarbon oxidation process, decided in 1959 that the unit was too small to be operated commercially.

Jefferson will use their new plant for intermediate-scale production of new products coming from its Austin, Texas, research laboratories, and for larger scale development of new processess pilot-planted at Austin. Slated for an early stage of its Conroe operations, says Jefferson, is development of a new process for morpholine, an intermediate used in rubber chemicals and corrosion inhibitors. Other intermediates for the polyurethane resin industry, and specialty surface-active agents are also scheduled for production at the new site.

The acquisition, according to Jefferson, is part of its long-range plans for "expansion and new development in ethylene and propylene oxide derivatives."

The plant, as taken over by Jefferson, consits of seven processing units operated from two control rooms, a process building with equipment for handling both liquids and solids, a hydrogen unit, control laboratory, and supporting utility services.



Processing equipment at Jefferson Chemical's newly-acquired Conroe, Texas, facilities.

Powdered polyethylene planned for U. S.

New applications and techniques developed in Europe expected to open new markets in this country.

FINELY DIVIDED POLYETHYLENE, which has found a number of applications in Europe, is expected to open new markets in this country in 1960 according to U. S. Industrial Chemicals Co. (National Distillers and Chemical). Semi-commercial quantities of this material will be available in March from U.S.I., which is scheduled to go onstream with a two million pound per year plant in Tuscola, Illinois.

Two types of powdered polyethylene will be available, one a low density, high melt index material, and the other an intermediate density,

continued on page 94

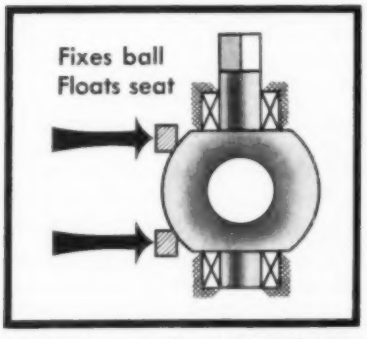
Can A Ball Valve Operate, Cycle After Cycle, With No Maintenance At All?

Read this remarkable answer, and discover an amazing engineering feat.

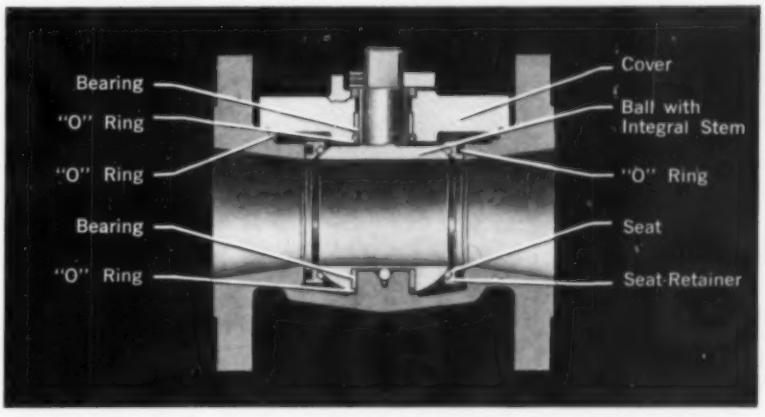
As most engineers know, ball valves offer a number of distinct advantages over all other types of valves . . . 90° on-off, minimum pressure drop, positive on-off indication, no lubrication, and compactness. In common with other valves, however, the design was insufficient to overcome the problem of continual maintenance.

Four years ago, this problem was faced by Hydromatics, Inc. in the valves that they produced for use in missiles, aircraft and ground support systems. Then, as today, all other ball valves were built with a ball that floated in its socket, and sealed by being forced against its seat by the pressure in the line. This caused seat distortion which made early replacement necessary.

Hydromatics tried a different approach. Rather than use the traditional floating ball, their engineers fixed the ball in bearings.



In the bearing-fixed **FLO•BALL** valve all pressure forces exerted on the ball are transmitted to low-friction bearings, thus eliminating down-stream seat distortion due to ball load. The pressure balanced seat, with its teflon sealing surface, is continually self-adjusted by the O-ring in the seat retainer.

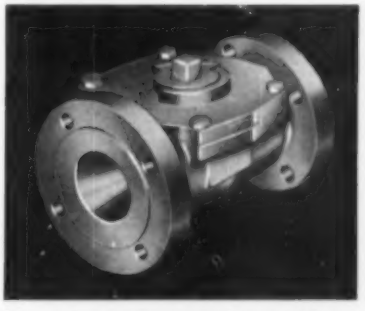


This O-ring acts as a self-energizing force that keeps the teflon seat always in contact with the ball. This insures positive sealing without seat distortion, and minimizes seat-resisting frictional forces. The combination of these low frictional forces results in low operating torque and extremely long seat life.

The bearing-fixed **FLO•BALL** valve proved itself immediately. Hundreds of missile and spacecraft systems, previously impossible, were made possible with these valves. The X-15, America's first manned space vehicle, for instance, has a Hydromatics **FLO•BALL** valve at its heart. Since its inception, the **FLO•BALL** has been used in more varied applications than all other ball valves combined.

Now, after the toughest application testing in history, bearing-fixed **FLO•BALL** valves are being mass produced for industry. They are available for off-the-shelf delivery to standard ASA dimensions in semi-steel, carbon steel, stainless steel, and aluminum. They operate at pressures to 600 psi, temperatures to 400°F and hold vacuum to 10^{-6} mm. of Hg!

The bearing-fixed **FLO•BALL** offers extra ball valve advantages. Top loading for easy access without removing the valve from the line, plus three features that are absolutely unique! Self-adjusting seats which automatically compensate for wear, proportional sealing force which automatically increases with line pressure, and the lowest torque, by far, of any valve. These combine to make the **FLO•BALL** valve virtually maintenance-free!



How long does it last without maintenance? Frankly, we don't know, since the first valves we ever built are still going strong and outlasting other valve types by more than 10-to-1. But don't take our word for it. See for yourself. Call, write or TWX for further information.

Hydromatics, Inc.
Livingston, New Jersey
Telephone: WYman 2-4900
TWX-LIVINGSTON NJ 120

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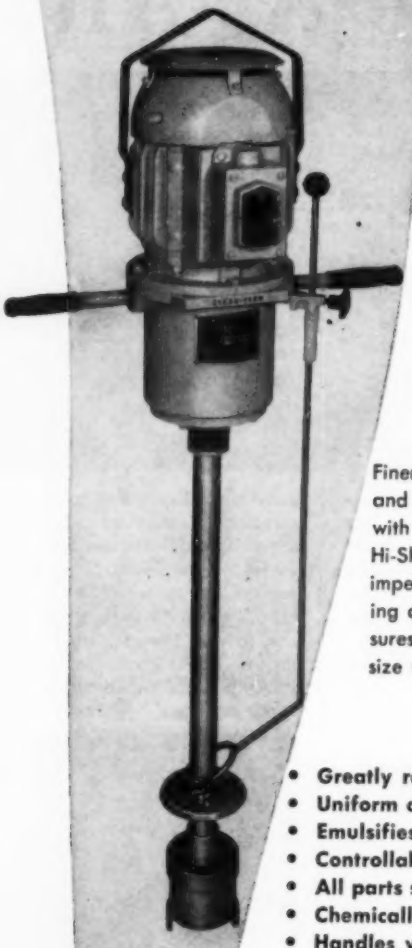

the modern mixer with power shearing

Finer, faster blending, dispersing and homogenizing is now possible with Shear-Flow's new Model RL Hi-Shear Head. Finely spaced dual impellers induce considerable shearing action and high pumping pressures that rapidly reduce particle size for superior material mixtures.

- Greatly reduces mixing time
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- Emulsifies immiscible liquids
- Controllable flow pattern
- All parts stainless steel
- Chemically inert seals
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- No operating Torque
- Disperses, blends, homogenizes

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☐ Send more information

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Position_____

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For more information, turn to Data Service card, circle No. 63

Polyethylene

from page 92

medium melt index material. Each type will be available in two forms: a very fine particle material made by a solution process; and a coarse material made by a new grinding technique. These new materials will be known as Microthene.

Applications

Potential uses that have been developed in Europe, and which can be applied to the American industry, include textile and fabric coatings, binder for non-woven fabrics, coatings for paper and metals, additives for waxes and polishes, and plastic molding of large polyethylene items.

Powdered polyethylene offers many new application techniques in addition to present extrusion and injection molding techniques which process pellets. By dispersing the powder in a liquid medium, a spraying or dipping technique can be used for coating regular or irregular shaped objects. In addition the dry powder forms a coating when contacted with a heated object, thus permitting possible use of fluidized-bed methods.

Spencer Chemical is also active in this area with an announcement for installation of grinding facilities and plans for a pilot plant to produce powdered polyethylene at Orange, Texas.

Census to compile occupation statistics

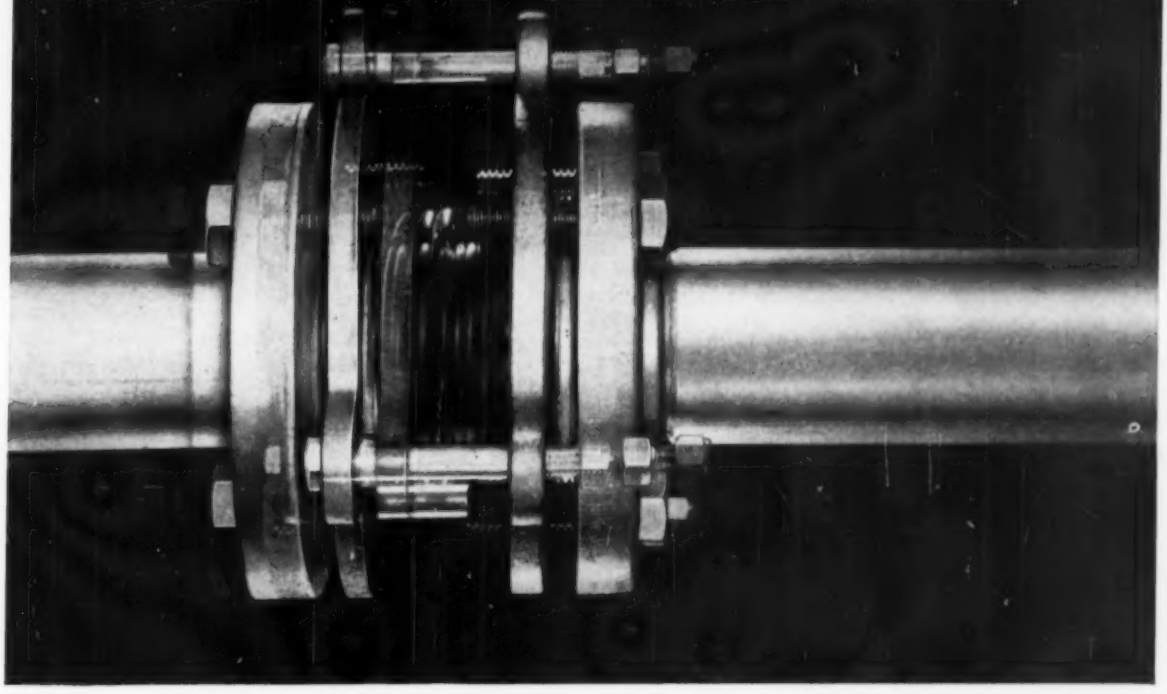
The 1960 Population Census will be conducted as of April 1. Every fourth household will be asked to answer the question "What kind of work was he doing?" for each person 14 years of age or older.

In order that the statistics on scientific and engineering manpower be developed as accurately as possible, the Census Bureau has asked that we pass along to our readers a reminder that this question on occupation should be answered completely and precisely. The entry should consist of at least two words in most cases.

Some examples of acceptable entries are:

Chemical engineer
Chemical engineer, process
Consulting chemical engineer
Chemical engineer, design
Estimating engineer, chemical
Project engineer, chemical
Petroleum refining engineer
Ceramic engineer

Is pipe VIBRATION your problem?



HERE'S HOW FLUOROFLEX®-T MOLDED FLEX JOINTS CAN SOLVE IT FOR YOU, FOREVER!

Fluoroflex®-T expansion joints *molded* from Teflon® can end your problem of absorbing pump or equipment vibration, misalignment, or expansion-contraction in any chemical piping system. They are not only unequalled in flex life, but also corrosion-proof to *any* processing fluid, except high-temperature fluorine and molten alkali metals!

Fluoroflex joints are unique in other ways as well:
1—Resistoflex's patented method of processing Teflon delivers maximum tensile strength and flex life.
2—Their *molded* construction provides joints with twice the burst strength, even after flexing, and 20 to 30 times the flex life of bellows machined from Teflon.
3—The higher ratio of burst pressure to operating pressure—at least 4 to 1—built into Fluoroflex-T joints assures wide safety margins.

With their long trouble-free life and excellent working pressure ratings, Fluoroflex joints can save you money, time, and headaches by preventing breakdowns and work stoppages. For all the facts, write for Bulletin B-1A, from Resistoflex Corporation, Roseland, N. J.

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equipment feature

Porous metal filters in nuclear fuel processing

Special design dispersion plate, and one-micron filter, are essential in a new fluidized-bed halogenation technique for recovery and reprocessing of uranium plate type fuel elements at Brookhaven National Lab.

A NEW FLUIDIZED-BED halogenation technique, developed at Brookhaven National Laboratory, has cut reprocessing time for uranium plate-type fuel elements from twenty-four to one and one-half hours.

Two methods are currently being used to recover uranium from spent fuels – the aqueous process and the volatility process. However, the aqueous process, traditionally the most popular, did not lend itself readily to reprocessing of sandwich plate design elements with zirconium-uranium centers and a zircaloy cladding on both sides. Serious corrosion problems presented themselves in the dissolution step and in waste storage.

To reprocess these spent fuel assemblies by the volatility method, reactions must be conducted at high temperatures (500°C for the hydrochlorination step; 400°C for the fluorination step). A gas-phase volatility treatment introduced serious problems related to the resultant heat from the highly exothermic gas-solid reaction. To control the heat, fuel plates had to be reacted for 24 hours to recover the same amount of uranium that the new fluidized-bed halogenation technique recovers in one and a half hours.

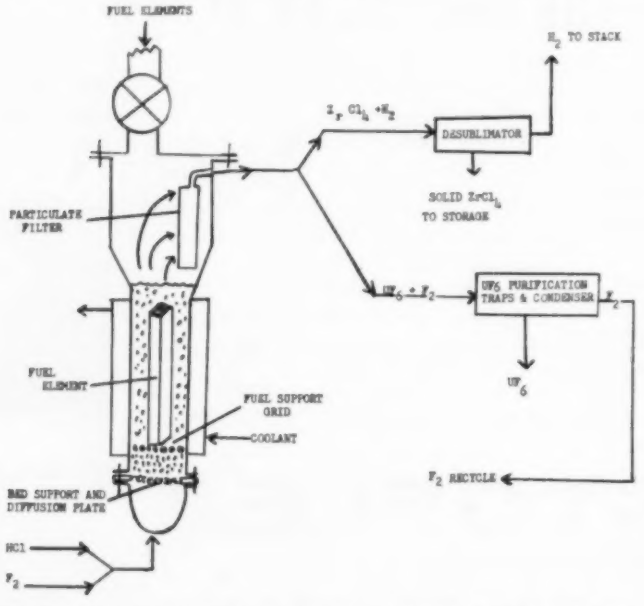
Called the Zircex process, the gas-phase volatility recovery technique was first studied at Oak Ridge, and subsequently modified at Brookhaven by introduction of an inert fluidized bed in which to conduct the reaction. There are two reasons for the greatly reduced time: the increased heat transfer capabilities of the inert bed, and a mixing action which removes reaction products as quickly as they are formed. In addition, the fluidized bed dilutes the small particles of uranium and fission products so efficiently that the waste heat handling problem is virtually eliminated.

Figure 1 outlines the fluidized-bed halogenation process used at Brookhaven. Design of the distributor or dispersion plate includes a metal edge filter cut across its cylindrical axis. The two halves are then placed at ninety degree angles to each other and fused with porous metal. This construction increases the strength of the plate in both directions. To ensure superior dispersion of the fluidizing agent, the fused metal edge element is then faced on the top and the bottom with the same porous metal, Inconel.

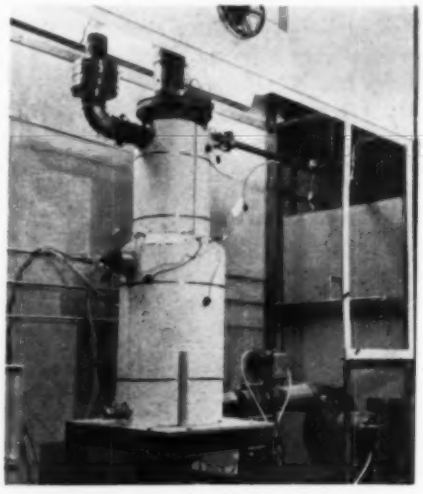
In the pilot-plant hydrochlorinator at Brookhaven, this six-inch wide distributor plate supports a fluidized bed approximately two feet deep. Without changing the plate design, a production-sized distributor plate, having the same diameter, will be strong enough to support a fluidized bed about six feet deep. In addition to the porous metal-faced distributor plate, the system includes an Inconel metal edge filter with an average pore size rating of one micron. This filter, a frameless, metal edge unit faced with porous metal, is located above the inert fluidized bed and positioned just in front of the off-gas line. It measures 3 inches in diameter by 15 inches long. Both the distributor plate and the filter were designed and built by Purolator Products, Inc. of Rahway, New Jersey.

The filter effectively screens the uranium chloride particles separated from the zirconium-uranium center during the hydrochlorination phase. In theory, proper control of the upward velocity of the hydrogen chloride gas –required to suspend the granular

continued on page 98



Fluidized-bed halogenation process for recovery of uranium from spent fuel.



Fluidized-bed reactor at Brookhaven–zirconium chlorination.

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4-inch, 300-pound Steel Bell-O-Seal "Y" Valve for molten metal service. It has hard faced seat and disc, and is electric motor operated.

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Powell has precision-designed special Valves to handle molten metals and other radioactive materials in atomic power plants—vital and hazardous fluids that must pass through the valves without the slightest leakage or failure.

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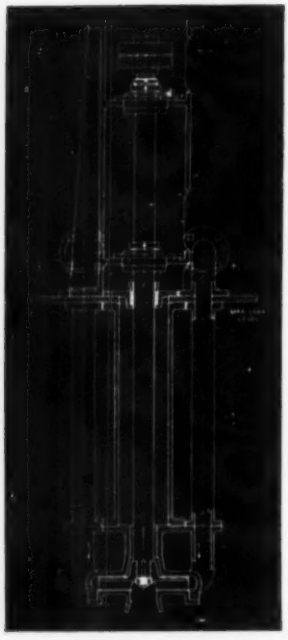
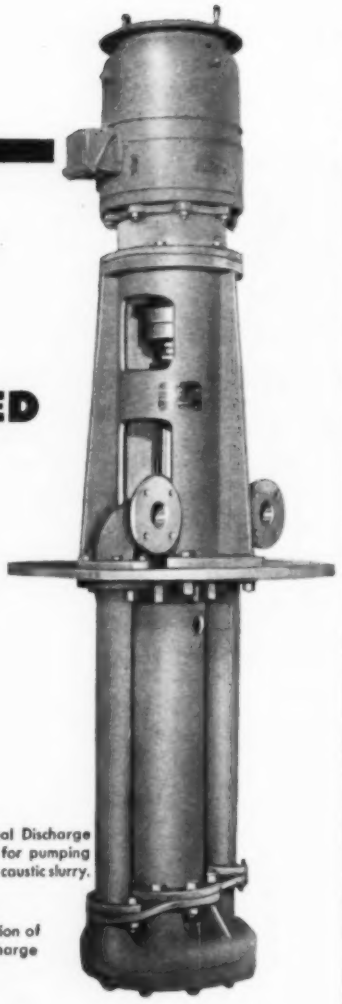
VERTICAL PUMPS WITH NO SUBMERGED BEARINGS FOR PUMPING ABRASIVE CORROSIVE SLURRIES



2" Dual Discharge Pump for pumping molten caustic slurry.



Cross section of Dual Discharge Pump.

This rugged type of service calls for advanced design: — extra heavy shaft, double-ported casing to equalize the side thrust of the impeller, and tough abrasion-corrosion resistant alloys. The dual discharge pump illustrated here incorporates these features and dispenses with bearings or packing below the cover plate where they would be in contact with the liquid.

Difficult pumping problems, particularly in the process industries, have been our specialty for ninety-one years. Perhaps we can be of help to you. Write us — no obligation.

LAWRENCE PUMPS INC.

Write for Bulletin 203-8 for complete summary of acid and chemical pump data.

371 MARKET STREET, LAWRENCE, MASS.

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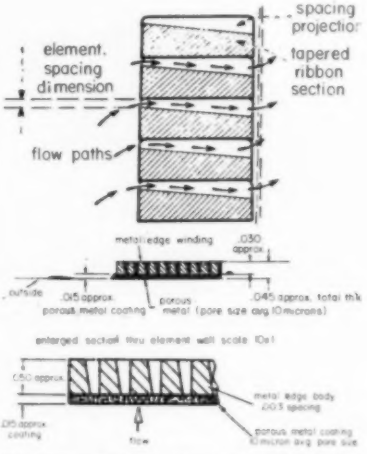
Porous metal filters

from page 96

solids in a fluidized state—should prevent any particles from rising above the inert bed. In practice, minute particles of uranium do rise above the bed. The metal edge filter holds particle loss to a minimum.

The filter, designed for the Brookhaven reactor, is formed by winding



(A) Cross-section view of metal-edge filter element. (B) Porous metal powder "faced" on metal-edge element—complete penetration. (C) Porous metal powder "faced" on metal-edge element—nominal "0" penetration.

a continuous spiral trapezoidal ribbon of Inconel into a cylindrical form. (Inconel was specified for both the filter and the distributor plate because of its resistance to HCl and F_2 at the high reaction temperatures). The Inconel ribbon has predetermined, spaced integral risers which accurately space one coil from the other. The height of the risers determines the degree of filtration. Since this is a frameless metal edge element, the risers are welded to the smooth adjacent face of the preceding helix to give a strong, firm, unitized structure. To increase the degree of filtration, the frameless metal edge filter was then coated on the outside with a porous metal Inconel powder.

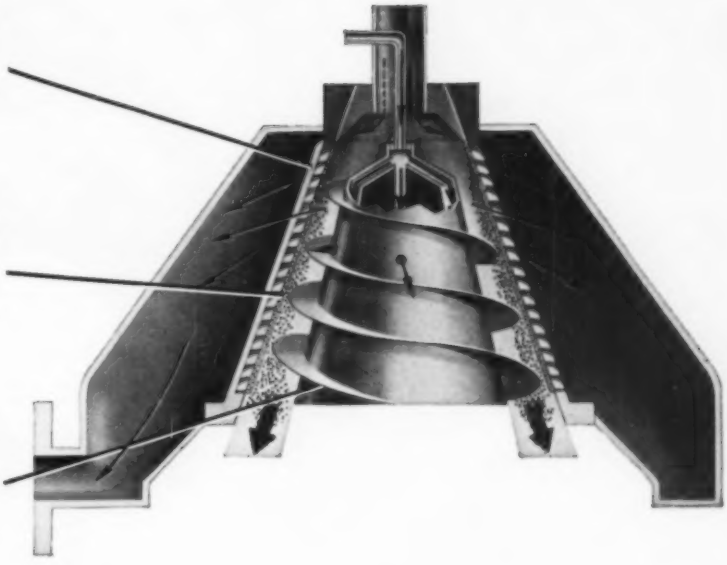
Filtration down to 1 micron was also specified for the second stage of the reaction—the fluorination stage. Here, the pure uranium hexafluoride separated from the fission products passes through the filter. Fluorine gas is dispersed through the porous metal-faced edge distributor plate at a temperature of 400°C. As the uranium separates from the fission products, the upward velocity of the fluorine carries UF_6 to a trap where it is condensed and collected.

1 2 3

the separating action of high centrifugal force (1800 x G) as the conical bowl assembly rotates at high speed.

the filtering action of the special perforate plate on which the solids are deposited and through which the mother liquor passes.

the metering action of the differential volute which controls the flow of solids downward at desired proper rate.



forces act on your slurry at the same time in the Sharples Continuous Dehydrator

For deliquefying crystalline solids and fibrous pulps at high capacity, Sharples offers 4 sizes of the Continuous Dehydrator with solids handling capacity up to 70 tons or more per hour.

A wide range of variables is inherent in the design and operation of this centrifuge; refinements which reflect in superior performance on each specific material.

The Sharples Continuous Dehydrator has proved to be an effective and profitable answer in numerous high capacity dewatering jobs. Get in touch with Sharples . . . specialists in making the most of solids from slurries.

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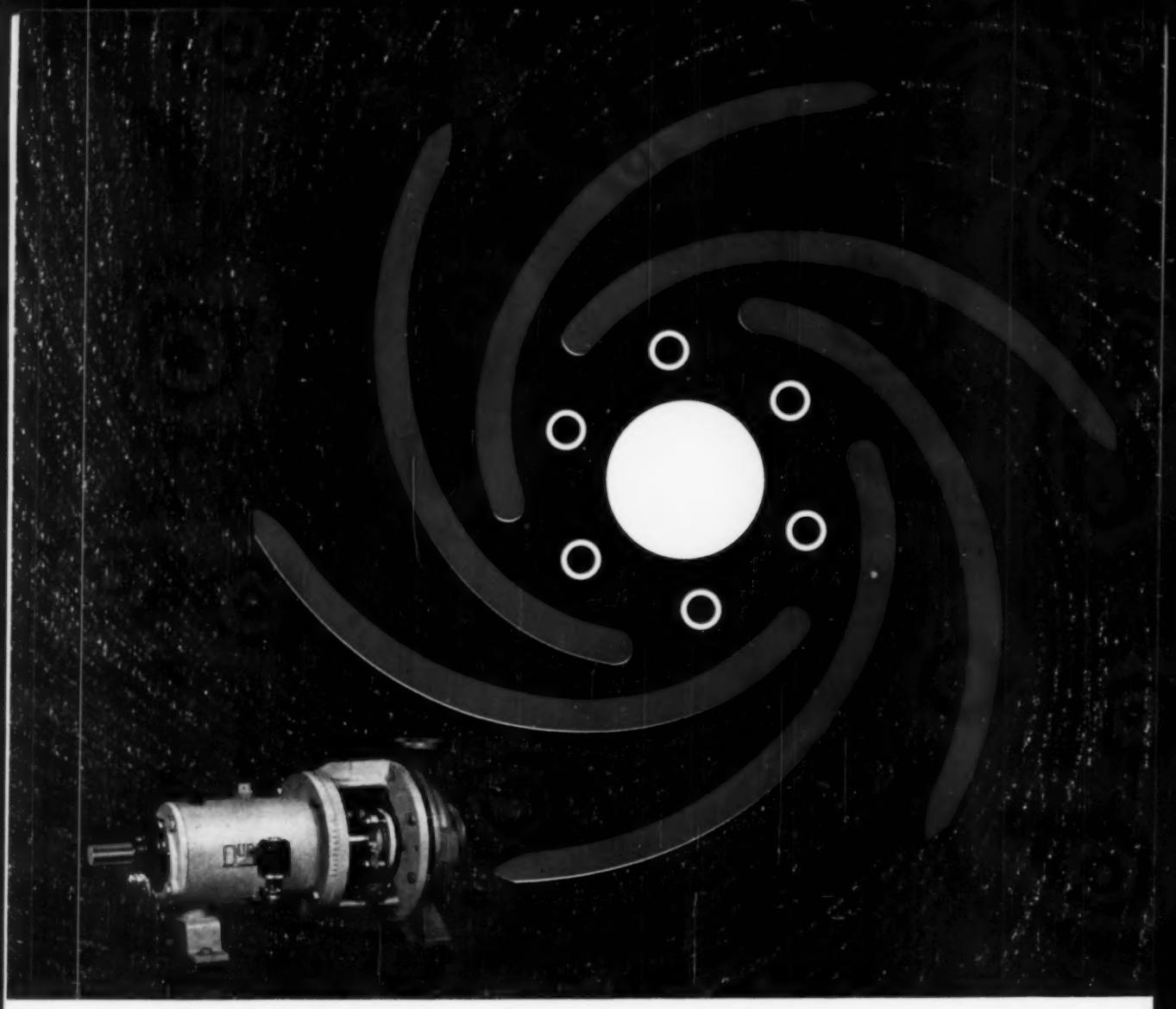

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Here is the first pump designed specifically for long life in heavy duty corrosive service.

Durcopumps are made in fourteen standard alloys and special materials. Four bearing housings plus separate frame adapters give maximum interchangeability for all pump sizes.

Maintenance is short and sweet because the working parts can be removed as a unit—in minutes—serviced and reinstalled by a single trade. Pump casing, piping and motor are not disturbed.

Durcopumps are produced in standard, self-priming and vertical submerged designs. Pumps are available with heads to 345 ft., capacities to 3500 gpm, in sizes from 1″ x 1″ to 10″ x 8″. Standard operating temperatures to 500° F.

Call your nearest Durco Service Engineer or write for literature on your service application.

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SUBJECT GUIDE to advertised products a

EQUIPMENT

Carriers, belt conveyor (p. 164). Bulletin 260 from Standard Products Div., Stephens-Adamson Mfg., describes the "Flexiroll" catenary carrier for belt conveyors. **Circle 40.**

Castings, high-alloy (p. 144). General Catalog G-159 from Duraloy has tables for selecting proper alloy for casting specs. **Circle 100.**

Centrifugals (p. 26). Bulletins from American Machine and Metals give details of the "Batch-O-Matic," made by its Tolhurst Div. **Circle 45.**

Centrifugals (p. 99). Data from Sharples on its Continuous Dehydrator, capacities to 70 tons/hour. **Circle 162.**

Compressors (p. 30-31). Technical data from Cooper-Bessemer. **Circle 54.**

Condensers (p. 13). Bulletin 5AA from Schutte and Koerting gives full details of wide range of condensers available for quick delivery. **Circle 143.**

Connections, pressure vessel (p. 22). Data from Lenape Hydraulic Pressing & Forging on weld ends and rings. **Circle 80.**

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MATERIALS

Acetone (p. 137-138). Data Sheet from U. S. Industrial Chemicals gives specifications, properties, uses, shipping info. **Circle 146-4.**

Coatings, plastic, extruded (p. 159). Info from Pyramid Plastics. **Circle 16.**

Chlorine (p. 109). Bulletin from Matheson gives specifications and properties. **Circle 126-2.**

Cobalt-60 (p. 131). Info from Atomic Energy of Canada on a complete Cobalt-60 service and source range. **Circle 1.**

Defoamers, silicone (p. 91). Info and trial samples available from Dow Corning. **Circle 129.**

Diatomites (p. 133). Info from Johns-Manville on filtration and mineral filler problems. **Circle 92.**

Ethyl Alcohol (p. 137-138). Info from U. S. Industrial Chemicals on use in vinegar manufacture. **Circle 146-1.**

Filter Aids (p. 136). Technical Data Brochure from Sil Flo gives info and prices. **Circle 131.**

Gases, compressed (p. 109). Complete Catalog from Matheson. **Circle 126-1.**

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VICES

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and Construction, wax plants
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FREE TECHNICAL LITERATURE

301	302	303	304	305	306	307	308	309	310	311	312	313	314	315
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EQUIPMENT *from page 101*

Containers, liquid helium (p. 171). Standard helium dewars in capacities from 5 to 100 liters, custom sizes and shapes for special requirements. Details from Superior Air Products. **Circle 51.**

Controls, liquid-level (p. 154). Info from Jo-Bell Products on the "Level Master." **Circle 132.**

Controls, visual (p. 185). Booklet BE-30 from Graphic Systems. **Circle 66.**

Controllers, pneumatic (p. 32). Data from Daystrom-Weston on complete family of recording and indicating pneumatic controllers. **Circle 29.**

Conveyors (p. 160). Technical data from Continental Conveyor & Equipment. **Circle 6.**

Crushers (p. 154). Bulletin from American Pulverizer gives technical data on crushers, shredders, and hammermills. **Circle 88.**

Dew Point Instrument (p. 167). Technical data from Illinois Testing Laboratories on the Alnor "Dewpointer." **Circle 37.**

Dosimeters (p. 166). Details from Landswerk Electrometer on Model L-49 200 MREM Thermal Neutron Dosimeter. **Circle 125.**

Dryers (p. 142). Data from C. G. Sargent's Sons on tray and truck dryers. **Circle 59.**

Dryers, indirect-fired (p. 130). Bulletin AH-438-40 from Hardinge gives details of Ruggles-Coles indirect-fired dryers and heaters. **Circle 161.**

Dryers, spray (p. 103). Editorial Reprint and Test Laboratory Booklet from Bowen Engineering. **Circle 158.**

Dryers, spray (p. 118). Data from Nichols Engineering & Research on the "Nerco-Niro" spray dryer. **Circle 15.**

Ejectors, jet-vacuum (p. 175). Bulletin from Jet-Vac. **Circle 58.**

Equipment, cryogenic (p. 166). Technical data from Ryan Industries, Cryogenic Div. **Circle 17.**

Equipment, tantalum (p. 23). Bayonet heaters, tapered condensers, thermowells, and custom equipment in tantalum. Details from Fansteel Metallurgical. **Circle 79.**

Feeders, bulk materials (p. 5). Catalog 804 from B. F. Gump gives technical details of the Draver feeder. **Circle 90.**

Filters (p. 27). Complete data from American Machine and Metals on

ubject guide to advertised products and services

RCLE CORRESPONDING NUMBERS ON DATA SERVICE CARD

Niagara filters. Capacities from 5 to 1,000 gal./min. **Circle 44.**

Filters (p. 28). Bulletins from American Machine and Metals on FEinc filters. Standard sizes from 5 to 800 sq. ft. of filtering area. **Circle 46.**

Filters (p. 116). Technical data from Buffalo Filters on its V S line. **Circle 60.**

Filter Media (p. 29). Bulletins from American Machine and Metals on FEON filter media. **Circle 43.**

Filter Papers (p. 126). Technical data and samples available from Eaton-Dikeman. **Circle 139.**

Filter Presses (p. 175). Catalog from D. R. Sperry gives complete details, including auxiliaries such as closing devices, plate shifters. **Circle 65.**

Forgings (p. 105). Technical info from Cameron Iron Works on split-die process for large and complicated ferrous forgings. **Circle 137.**

Heat Exchangers (p. 21). Available from stock in 3 standard sizes. Info from Whitlock Mfg. **Circle 140.**

Heat Exchangers, graphite-block (p. 168). Pressures to 200 lb./sq. in., temperatures to 360°F. Kearney Industries, Delanium Graphite Div. **Circle 98.**

Heat Exchangers, panel-coil (p. 24). Data Sheet 15-60 Series and Price Bulletin 259 from Dean Products. **Circle 81.**

Heat Exchangers, plate-type (p. 10). Engineering details from Chester-Jensen. **Circle 53.**

Heat Exchangers, standardized (p. 161). Bulletin 820 from Manning & Lewis describes complete line. **Circle 64.**

Heating Units, induction, high-frequency (p. 159). Technical data from Lepel High Frequency Laboratories. **Circle 134.**

Joints, expansion (p. 95). Bulletin B-1A from Resistoflex gives details of Fluoroflex expansion joints molded from Teflon. **Circle 23.**

continued on page 104

MATERIALS *from page 101*

Graphite (p. 117). Great Lakes Carbon announces acquisition of plant of Crescent Carbon Corp., Antelope Valley, Calif. **Circle 35.**

Heat Transfer Cement (p. 165). Bulletin 300 from Thermon Mfg. describes non-metallic adhesive cement with efficient heat transfer properties. **Circle 83.**

DL-Methionine (p. 137-138). Data from U. S. Industrial Chemicals on use in treatment of chronic peptic ulcers. **Circle 146-2.**

Pentanedione (p. 107). Technical Bulletin from Union Carbide Chemicals gives physical properties, specifications, shipping info on 2, 4-pentanedione. **Circle 97.**

Steels, stainless (p. 114). Plates, heads, rings, circles, flanges, forgings, bars and sheets. Data from G. O. Carlson. **Circle 28.**

Thorium (p. 136-137). Info from U. S. Industrial Chemicals on new sodium reduction process, reported to give very high-purity thorium. **Circle 146-3.**

Urea, biuret formation from (p. 137-138). Info from U. S. Industrial Chemicals gives data on rate of biuret formation from urea. **Circle 146-5.**

Yttrium (p. 8). High-purity yttrium metal now available in developmental quantities. Details from Michigan Chemicals, Rare Earths and Thorium Div. **Circle 13.**

SERVICES *from page 101*

Fabrication, process equipment (p. 88-89). Data from C. H. Wheeler Mfg. on its union with Griscom-Russell. Brochure. **Circle 41.**

Fabrication, process equipment (p. 134). Info from Goslin-Birmingham on evaporators, dryers, filters, etc. **Circle 138.**

Fabrication, process equipment (p. 139). Bulletins from Doyle & Roth cover storage tanks, heat exchangers, pressure vessels, etc. **Circle 159.**

Fabrication, process equipment (p. 145). Data from General American Transportation on "Process Dynamics," new concept for evaluation and control of equipment and process performance. **Circle 8.**

Fabrication, process equipment, cryogenic (p. 113). Storage vessels of special design for low temperature work. Technical details from Chicago Bridge & Iron. **Circle 56.**

Nuclear Literature (p. 163). Data from United Nations on Proceedings of Second International Conference on Peaceful Uses of Atomic Energy. **Circle 135.**

MISCELLANEOUS

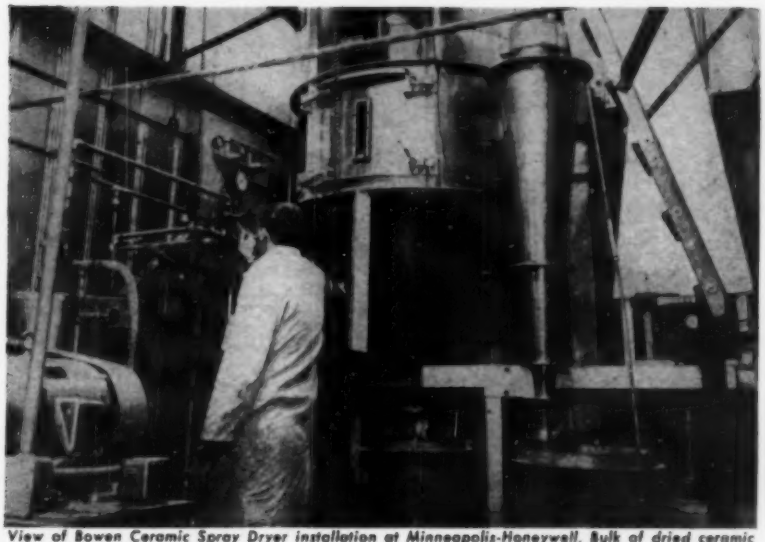
Automobiles (p. 153). Engineering details from Oldsmobile Div., General Motors. **Circle 127.**

FACTS FIGURES AND IDEAS FROM BOWEN ENGINEERING, INC.

Spray drying NEWS

VOLUME 2, NO. 2

RECOGNIZED LEADER IN SPRAY DRYING SINCE 1926



View of Bowen Ceramic Spray Dryer installation at Minneapolis-Honeywell. Bulk of dried ceramic particles are collected directly at base of dryer (center) while remaining particles are cyclone-collected (right).

Minneapolis-Honeywell Finds Spray Drying Key to Substantial Savings in Production of Ceramic Parts

Rejects Cut As Titanates, Zirconates, Aluminas and Other Electronic Ceramics Are Spray Dried To Precise Quality Specifications

PROBLEM—For economical manufacture of their numerous electronic ceramic specialties, Minneapolis-Honeywell required a drying method that would permit inexpensive, short-run production of a wide variety of ceramic compositions—some with over a dozen ingredients. Furthermore, the method had to overcome problems being encountered with oven drying, such as floating out of binders and wide variations in particle size and shape, that made dry pressing difficult and led to a high percentage of rejects of finished ceramic parts.

SOLUTION—Minneapolis-Honeywell found the answer to their problem in a compact, 4½-foot diameter Bowen Ceramic Spray Dryer designed especially for moderate production runs of a wide range of different ceramic materials. Constructed of stainless steel and equipped with the patented Bowen abrasion-resistant, two-fluid atomizing nozzle, this highly versatile unit today is regarded as a "must" in M-H operations. It handles slurries of 55% to 65% solids and consistently produces homogeneous, free-flowing products of the uniform particle sizes and shape required for dependable dry pressing of precision ceramic parts. Spray dried compositions range all the way from 100% clays to 100% non-plastics, with sundry variations in between. Clean-up time from one product run to another is usually about 20 minutes.

BENEFITS—Substantial savings have been enjoyed by Minneapolis-Honeywell since adopting the spray drying process. For example, the exceptional uniformity of a spray dried material has meant that if the first several parts pressed meet specifications, M-H can be almost certain that the remainder of the press run—as many as several thousand units—will pass inspection. Percentage of rejects has been reduced and the resultant savings have contributed greatly to fast write-off of installation cost. In addition, operating labor costs have been lowered and little dryer maintenance has been required in nearly two years of operation.

Indicative of M-H's satisfaction with the spray drying process and the flexibility and convenience of Bowen equipment is their recent purchase of a duplicate unit to meet expanding requirements.

For more information on the foregoing installation, write for Editorial Reprint MH.

SPEAKING FOR BOWEN

JOSEPH J. QUINN, JR., *Bowen Vice President, discusses economic factors involved in accurately appraising the spray drying process.*

ECONOMIC CONSIDERATIONS IN EVALUATING SPRAY DRYING

Contrary to a popular misconception, spray drying can be inherently as efficient as any other drying method. In many cases, such as with heat-sensitive materials, higher temperatures than permissible with alternate methods can be used to secure greater fuel economy. This is possible because spray dried materials never reach the temperature of the dryer inlet air.

Yet thermal efficiency is only one of several factors that must be considered in order to fully appreciate the economic benefits of the spray drying process. For example:

Frequently, it is possible to integrate spray drying into a given process in such a way as to completely eliminate costly handling steps formerly required. Resultant labor savings can exceed fuel savings involved—or can compensate many times over for slightly higher fuel costs if fuel requirements are greater than before. Similarly, spray drying in some instances can eliminate or simplify subsequent processing steps to provide tremendous savings in operating costs. Or spray drying may cut over-all manufacturing costs substantially by reducing the percentage of rejected material.

Finally, the possibility of improved product quality—or the possible achievement of unique, beneficial product characteristics—must not be overlooked. In case after case, spray dried products have commanded premium prices that alone have more than justified the cost of a spray dryer installation.

Check items desired, clip and mail with your name, title and company address to Bowen Engineering, Inc., North Branch 13, N. J.

☐ Editorial Reprint MH

☐ Bowen Test Laboratory Booklet

Information on the feasibility of spray drying:

_____

_____

BOWEN ENGINEERING, INC.
North Branch 13, N. J.

For more information, turn to Data Service card, circle No. 158

CEP'S DATA SERVICE—Subject guide to advertised products and services

CIRCLE CORRESPONDING NUMBERS ON DATA SERVICE CARD

EQUIPMENT *from page 102*

Joints, flexible, ball (p. 132). New Revised Bulletin 31-A, "How to Solve Piping Flexibility Problems." Barco Mfg. **Circle 3.**

Level Indicator, bins (p. 173). Prevents overflowing of bins, clogging of conveyors, etc. Data from Bin-Dicator on the new automatic "Auto-Bin-Dicator." **Circle 5.**

Mill, cage (p. 162). Handles wet, sticky or gummy materials without plugging or slowing the operations. Data from Stedman Foundry and Machine. **Circle 19.**

Mills, grinding, impact (p. 115). Lower percentage of fines or oversizes by absolute control of impact velocity. Data from Entoleter Div. of American Manufacturing. **Circle 101.**

Mills, three-roll (p. 170). Info from Charles Ross & Son on new high-speed model with one-point hydraulic roll adjustment. **Circle 39-1.**

Mixers (p. 9). Handbook on mulling from Simpson Mix-Muller Div., National Engineering. **Circle 38.**

Mixers (p. 94). Data from Gabb Special Products on the "Shear-Flow" mixer. **Circle 63.**

Mixers, change-can (p. 170). Data from Charles Ross & Son on production size dispersion type with double planetary stirrer action. **Circle 39-2.**

Mixers, laboratory (p. 173). Technical data from Rapids Machinery on the Marion mixer. **Circle 130.**

Mixer, low-cost (p. OBC). Info from Mixing Equipment on new lower-cost Series RE mixers. **Circle 163.**

Nozzles, spray (p. 161). Catalog 1 from Monarch Mfg. Works. **Circle 85.**

Nozzles, spray (p. 162). Complete Catalog from Spray Engineering. **Circle 89.**

Nozzles, spray (p. 172). Catalog 24 from Spraying Systems. **Circle 26.**

Packings, interwoven asbestos (p. 185). Bulletin SLP-659 gives service conditions, applications, prices on Palmetto packings. Greene, Tweed. **Circle 55.**

Packing, tower (p. 143). Comprehensive Booklet from Harshaw Chemical discusses application of "tellerettes" to tower packing. **Circle 33.**

Piping, glassed-steel (p. 151). Bulletin 989 from Pfaudler Permutit gives details on "Glasteel" pipe. **Circle 76-1.**

Processor, (p. 152). Info from Kontro on applications of its tapered processor. **Circle 86.**

Pulverizer (p. 141). Info from Strong-Scott Mfg. on the "Pulvocron", impact and air attrition pulverizer combined with internal particle size classifier. **Circle 61.**

Pumps (p. 12). Bulletin 300 from Weinman Pump Mfg. gives details of the "Unipump," in capacities from 10 to 1,700 gal./min. **Circle 99.**

Pumps (p. 119-120). Technical details from Eco Engineering on several types. **Circle 145.**

Pumps, controlled-volume (p. IBC). Technical data from Milton Roy. **Circle 47.**

DEVELOPMENT OF THE MONTH

MODULAR ENTRAINMENT SEPARATOR

(Circle 603 on Data Post Card)

Entrainment separator modules made of impervious graphite for effective separation of entrained liquids from corrosive gas streams are available from National Carbon Co., Div. of Union Carbide Corp.

The modules are reported to have high collection efficiencies and low pressure drop and operate on the principle of impingement plus venturi action. The dimensions of the module are one by two ft. and consist of staggered rows of streamlined rods with ¼-in. clearance to prevent clogging.

These modules can easily be assembled into banks to fit any duct or process vessel.

For more information from National Carbon, Circle 603 on Data Post Card.

Pumps, corrosion resistant (p. 100). Heads to 345 ft., capacities to 3,500 gal./min., operating temperatures to 500°F. Duriron. **Circle 160.**

Pumps, screw (p. 128). Horizontal or vertical constructions. Corrosion resistant alloys, special bodies, stuffing boxes and bearings for special needs. Details from Sier-Bath Gear & Pump. **Circle 21.**

Pumps, vertical (p. 98). Bulletin 203-8 from Lawrence Pumps gives complete summary of acid and chemical pump data. **Circle 50.**

Reactors, stainless steel (p. 151). Technical details and specifications in Bulletin 944 from Pfaudler Permutit. **Circle 76-2.**

Rectifiers (p. 163). Sel-Rex offers "Guide" to Industrial Rectifier Equipment. **Circle 20.**

Refrigerating Unit, small-scale (p. 174). Info from Fisher Governor on the Hilsch Vortex Tube, for small-scale laboratory or industrial cold air requirements. **Circle 7.**

Refrigeration Equipment (p. 36). Graham Mfg. offers data on the "Jet-Mizer" steam vacuum refrigeration machine equipped with the "Aquadyne" vacuum condenser. **Circle 75.**

Refrigeration Equipment, jet vacuum (p. 121). Info from Croll-Reynolds on the "Chill-Vactor." **Circle 49.**

Rotameters (p. 169). Positive indication, all-metal construction, thru-bolted design. Bulletin 130 from Brooks Rotameter describes the "Ar-Met." **Circle 34.**

Rotameter, pneumatic, transmitting (p. 172). Bulletin 18B from Schutte and Koerting gives details of new "position-balance" type. **Circle 18.**

Screeners (p. 160). Complete technical details on the "Vorti-Siv" from J. M. Lehmann. **Circle 103.**

Separation Equipment (p. 25). Technical data from American Machine and Metals on Tolhurst centrifugals, Niagara pressure filters, FEinc continuous filters, FEON filter media. **Circle 42.**

Separation Equipment, solid-liquid (p. 125). Data from Bird Machine on centrifugals and filters in wide range of types, sizes, and designs. **Circle 2.**

Separators, entrainment (p. 4). Technical Reprint 591 and Bulletin 21 from Otto H. York give technical details. **Circle 133.**

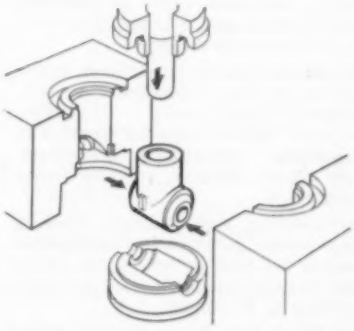
Separators, entrainment, knitted-wire (p. 171). Bulletin ME-9 from Metal Textile Corp. has latest design guides. **Circle 93.**

continued on page 106

CAMERON SPLIT-DIE FORGINGS FOR NUCLEAR POWER PLANTS

The Cameron split-die process has made ferrous forging history in components for extreme service. These AISI Type 304 stainless steel check valve bodies for nuclear power plants are another chapter in the same story. The Cameron processes were perfectly suited to produce these unusual forgings. Even though test requirements exceeded all normal procedure, we were ready to meet the exacting specifications and complete another forging contract. Most important, performance in end use could be predicted and fear of failure eliminated.

Ferrous forgings to 8,000 lbs. produced by this method emerge from our presses in near final form. A vast array of shapes and sizes, heretofore impossible to forge in one piece, are now solving knotty problems in many demanding applications.



Every single production phase from melting the high quality steels for our ingot supply through blooming, forging and heat treating to final machining is performed in our shops under constant control. Men, instruments and machines are teamed to make results predictable. Grain structures in these remarkable forgings are excellent, welds are eliminated, and machining is made easier. The result is a better component which often costs less.

Extending the design scope of ferrous forgings has made Cameron important in solving many problems which confront advanced design today. Extreme service components for airframes, jet engines, guided missiles and a wide variety of other end uses are finding a solution in the Cameron split-die forging process. If you have a problem . . . call, write or come by

Cameron

IRON WORKS, Inc.

SPECIAL PRODUCTS DEPARTMENT
P. O. Box 1212, Houston, Texas

For more information, turn to Data Service card, circle No. 137

CEP'S DATA SERVICE—Subject guide to advertised products and services

CIRCLE CORRESPONDING NUMBERS ON DATA SERVICE CARD

EQUIPMENT *from page 104*

Size Reduction Equipment (p. 167). Info from Sturtevant Mill on jaw crushers, rotary fine crushers, crushing rolls, hammer mills. **Circle 27.**

Strainers (p. 164). Stocked in 2, 2½, 3, 4, and 6 in. sizes, all flanged. Details from Schutte and Koerting. **Circle 32.**

Tanks (p. 158). New 16-page Catalog from Littleford Bros. gives details of all types, shapes, sizes. **Circle 102.**

Tanks, rubber-lined (p. 150). Wide variety of rubber and plastic lining materials. Data from Gates Rubber. **Circle 24.**

Tanks, stainless (p. 150). Technical details from Filpaco Industries on all types of storage and mixing tanks. **Circle 87.**

Thermocouples, sheathed (p. 169). Bulletin 1200-4 gives complete details, ordering data, prices on sheathed thermocouple wire and accessories. Claud S. Gordon. **Circle 57.**

Tubing, finned (p. 19-20). Design and Cost Comparison Book from Wolverine Tube gives complete data on "Trufin" integrally-finned tube. **Circle 157.**

Tubing, plastic (p. 85). Bulletin T-100 from U. S. Stoneware on "Tygon" plastic tubing, resistant to broad range of corrosive gases and chemicals. **Circle 52.**

Tubing, Teflon (p. 170). Chemical inertness, non-flammability, abrasion resistance, zero moisture absorption. Details from L. Frank Markel & Sons. **Circle 91.**

Valves, ball-plug (p. 7). Wide range of sizes and ratings. Catalog V-60 from Hydril. **Circle 78.**

Valves, "Flo-Ball" (p. 93). Data from Hydromatics on new design of ball valve —minimum pressure drop, positive on-off indication, no lubrication. **Circle 36.**

Valves, nuclear (p. 97). Complete technical data from Wm. Powell Co. **Circle 96.**

Valves, precision (p. 14). Details from Kieley & Mueller on precision valves, specially adapted for nuclear work. **Circle 11.**

Valves, safety-relief (p. 165). New design uses Pyrex and Teflon construction for full visibility and corrosion resistance. Bulletin RV-1 from Chem Flow. **Circle 82.**

Viscometer (p. 148). Continuous measurement, recording, and control of viscosity. Info from Brookfield Engineering Laboratories on the "Viscometran." **Circle 30.**

Washers, fume (p. 155). Bulletin 90 from Maurice A. Knight gives data on operation and construction, capacities, pressure drops, horsepower. **Circle 144.**

Water Conditioning Equipment (p. 168). Deionizers, ion exchangers, chemicals, engineering, consulting, research. Bulletin 512 from Elgin Softener. **Circle 25.**

Weigher, continuous (p. 111). Bulletin 958 from Stephens-Adamson Mfg. gives complete technical details. **Circle 84.**

Wire Cloth (p. 90). In stainless, Monel, Nichrome, phosphor bronze, aluminum, brass, copper. Bulletin F-C from Newark Wire Cloth Co. **Circle 14.**

SUBJECT GUIDE to free technical literature

CIRCLE CORRESPONDING NUMBERS ON DATA SERVICE CARD

EQUIPMENT

301 Analyzer, oxygen. Literature describes instrument for continuous measurement of oxygen in flue gases, liquefied air processes, etc. Data from Milton Roy Co.

302 Blender, conical. Information for one-foot glasteel conical dryer blender for small pilot plants available from Pfaudler Co.

303 Centrifuge. Information from Baker Perkins Inc. describes new centrifuge for removing solids like polyolefins, resins, titanium from liquid carrier at pressures to 150 lb./sq. in. and speeds to 1000Gs.

304 Centrifuges. New 16-page Catalog from Lourdes Instrument Corp., Div. of Labline describes 13 improved super-speed centrifuges with capacities to 3000 ml. and speeds to 18,000 rpm.

continued on page 108

MATERIALS

365 Additives, gasoline. Special report "Gasoline Anti-stalling Additives" from Armour Industrial Chem. Co. completely describes tests of aliphatic surface active agents in reducing stalling of automobile engines.

366 Aliphatic Organic Chemicals. Bulletin from Armour Industrial Chem. Co. presents applications, properties, chemical compositions for fatty acid derivatives, ethoxylated chemicals, polar organic nitrogen, complex amino compounds.

367 Catalyst, hydrogenation. Product Data Sheets and detailed methods of analysis for high activity liquid phase palladium-carbon hydrogenation catalyst from W. R. Grace.

368 Chemicals. Comprehensive Guide lists physical properties and shipping information for complete line of chemicals from Union Carbide Olefins Co.

continued on page 108

SERVICES

392 Corrosion Chart. New corrosion resistance chart lists over 150 chemicals and recommends materials of construction for satisfactory operation. Data from OPW-Jordan.

393 Corrosion Samples. Bulletin 981 lists Glasteel and alloy test samples available from Pfaudler Co. for laboratory testing of materials of construction in corrosive environments.

394 Dictionary, equipment guide. Seventy two page Adaptioneering Dictionary from Sprout, Waldron & Co. presents alphabetical list of free-flowing dry materials and slurries with process equipment for handling.

395 Equipment, Processes, Service. New 12-page Brochure describes equipment, processes, services available to chemical process industries from De Laval Separator Co.

continued on page 108

Progress Report... Pentanedione

New chelates with 2,4-pentanedione

Metal chelates provide a means of deactivating or modifying the properties of a metal ion. Effective chelating agents with many industrial applications can be formed by the reaction of CARBIDE's 2,4-pentanedione (acetylacetone) with numerous metals and oxides.

Pentanedione, or acetyl acetone, usually forms oil-soluble metal derivatives, whereas most other chelates are water-soluble. Certain of these chelates may have possibilities as fungicides, insecticides, driers for paints and varnishes, and colors for inks. Titanium pentanedionate is indicated as an excellent cross-linking agent for cellulose-derivative films and coatings giving them high solvent resistance.

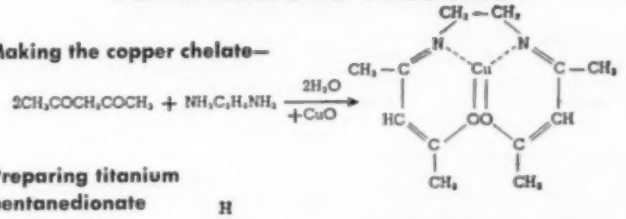
Here are some other ideas . . . By adding a small amount of 2,4-pentanedione to a water solution of a coating-metal salt, hard and bright films can be laid on baser metals without an electric current. The discoloration of cyclic carbonate spinning solutions of acrylonitrile polymers can be inhibited by adding 0.1 to 3.0 per cent 2,4-pentanedione to the solution. Butadiene may be copolymerized with 2,4-pentanedione to produce an improved grade of synthetic rubber, suitable for industrial uses. A granular, water-insoluble, anion-active resin can be made with 2,4-pentanedione as the reactive ketone. The soluble metal derivatives of 2,4-pentanedione should be evaluated for their ability to increase the efficiency of internal combustion engines when added to lubricating oils.

Remember, CARBIDE's 2,4-pentanedione is fully miscible with most organic solvents. Its molecular weight of 100.1 also makes it interesting as an intermediate. For more information a technical bulletin containing many suggestions for applications of CARBIDE's 2,4-pentanedione is available. In it are listed physical properties, specifications and shipping information. For information on other CARBIDE chemicals, write for the 1960 Physical Properties of Synthetic Organic Chemicals—a comprehensive description of the properties and applications of more than 400 CARBIDE chemicals. Please write to Dept. HP, Union Carbide Chemicals Company, 30 East 42nd Street, New York 17, N. Y.

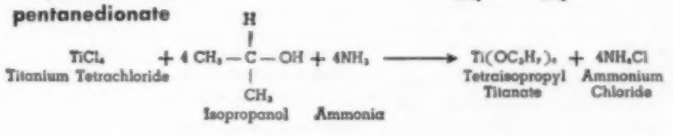
"Union Carbide" is a registered trade-mark of Union Carbide Corporation.

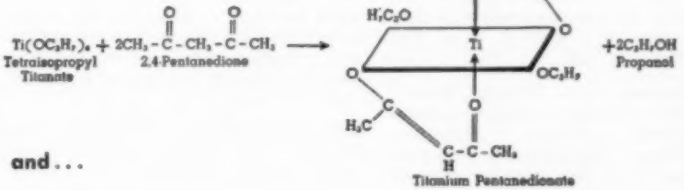
PENTANEDIONE CHELATES

Making the copper chelate—



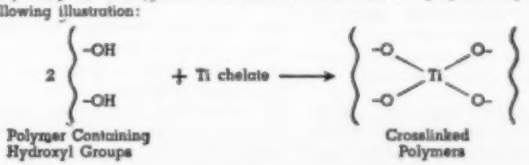
Preparing titanium pentanedionate





and . . .

The crosslinking effects of this material on a cellulose derivative polymer may be shown by the following illustration:



UNION CARBIDE CHEMICALS COMPANY
DIVISION OF
UNION CARBIDE CORPORATION

For more information, turn to Data Service card, circle No. 97

CEP'S DATA SERVICE—Subject guide to free technical literature

CIRCLE CORRESPONDING NUMBERS ON DATA SERVICE CARD

EQUIPMENT *from page 106*

305 Chain and Sprockets. A 56-page engineering Bulletin from Dodge Mfg. Corp. gives selection data, prices, H.P. ratings, practical calculations, installation data for complete line of roller chain and Taper-Lock sprockets.

306 Compressor, stationary. New 24-page Bulletin from Joy Mfg. Co. includes specifications for three basic models of semi-radially constructed units from 1385 to 1948 cu. ft./min. at 125 lb./sq. in. pressure.

307 Control Panels. New 12-page Bulletin from Fuller Co. describes control panels for automatic handling of dry materials in chemical process industry.

308 Controls. New 56-page Catalog presents description, specifications, and engineering data for mercury switch equipped pressure, temperature, and liquid level controls. Catalog from Mercoid Corp.

309 Controls, liquid level. New product release from Magnetrol, Inc. describes non-metallic liquid level controls for handling a complete line of chemicals safely.

DEVELOPMENT OF THE MONTH

URETHANE FOAM ADDITIVE (Circle 601 on Data Post Card)

A new silicone-glycol copolymer, Dow Corning 199, is available from Dow Corning for use as a cell-control additive in one-shot polyurethane foams.

Advantages to foam manufacturers are reported to be: lower foam density, lower cost, firm foam structure during rise period, faster foam processing, and fine uniform cell distribution throughout finished foam.

The photograph above compares a foam that used the additive and one that had no additive. Formulations call for about 0.5 per cent additive for one-shot flexible foams.

The new silicone is reported also to be effective in rigid foam production.

For more complete details, Circle 601 on Data Post Card.

310 Cooler, multiple tube. Leaflet from Allis-Chalmers tells how multiple-tube cooler designed for fine, soft or granular materials operates to save money.

311 Coolers, grate. Bulletin from Fuller Co. describes, explains features for both horizontal-grate and inclined-grate coolers.

312 Covers, pressure vessel. Description of quick opening automatic pressure vessel covers for process equipment from J. P. Devine Mfg. Co.

314 Crusher, single roll. Details from Sprout, Waldron & Co. describe 24-in. single roll crusher for handling variety of materials such as coke, sulphur, clay, salt, urea, etc.

315 Equipment, fluid processing. Sixteen-page Buyer's Guide covers equipment and services available for fluid-handling problems. Information from Pfaudler Permutit Inc.

continued on page 110

MATERIALS *from page 106*

369 Epoxy Resins. Information concerning new and different epoxy resins with unique structure, reactivity, curing characteristics from Food Machinery and Chemical Corp.

370 Insulation, mica paper. Literature describing characteristics, forms, typical applications for electrical insulation from Mica Insulator Div. of Minnesota Mining & Mfg.

371 Insulation, urethane-foam. Information concerning availability, efficiency, properties of rigid, urethane-foam pipe insulation from Union Asbestos & Rubber Co.

372 Isotope, helium-3. Information concerning 90% reduction of price and availability for low-temperature nuclear experiments of helium-3 from Oak Ridge National Lab.

373 Ketones. New 48-page Booklet from Union Carbide Chemicals includes applications, physical properties, formulations, physiological properties for ketones to be used as solvents and chemical intermediates.

374 Lubricant, synthetic. Technical Data Report on ester-based synthetic lubricant from Eastman Chemical Products gives physical properties, corrosion stability, foaming characteristics.

375 Materials, asbestos, insulation. Latest edition of 10-page Buying & Selling Guide entitled "Asbestos and Insulating Materials" is offered by Grant Wilson, Inc.

376 Metals, lead lined. Sixteen-page Technical Data release from Knapp Mills, Inc. presents properties, characteristics, uses of lead-surfaced aluminum, copper, steel for radiation and corrosion shielding.

377 Mineral Fillers. Data for extremely pure, non-abrasive, completely inert, neutral mineral fillers of uniform sub-micron particle size are available from Sil-Flo Corp.

378 Packings, polypropylene. Information for new polypropylene Pall Ring tower packing combining light weight, low pressure drop, high mass transfer efficiency, chemical inertness from U.S. Stoneware Co.

continued on page 110

SERVICES *from page 106*

396 Facilities, chemical. Twelve-page Brochure describes plant, research facilities, operating processes, custom process facilities of Crestwood Chemicals (Chemetron Corp.).

397 Fluoroscopy, pipe testing. New 12-page Booklet entitled "A Progress Report on Continuous Fluoroscopic Inspection of Submerged-Arc Welded Line Pipe" from Philips Electronic Instruments.

398 Heat Loss Calculations. Folder from Baldwin-Ehret-Hill, Inc. includes a reprint entitled "How to Compute Heat Losses Graphically" for quickly calculating heat loss from insulated surfaces under various ambient conditions.

399 Industrial Tracers. Twenty-eight page Catalog from Tracerlab describes use of industrial tracers in the oil industry.

400 Pilot Plant Facilities. New pilot plant facilities containing pilot model spray dryer, set of various interchangeable collectors, fully automatic control panel available to industry at Wisconsin plant of Henszey Co.

401 Thermoforming Techniques. New Bulletin from Comet Industries designed to give production men a better knowledge of machinery function, material characteristics, and performance required of vacuum forming machines.

402 Vacuum Induction Melting, super alloys. New 36-page Brochure "Superalloys by Vacuum Induction Melting" discusses present, future applications of superalloys, describes vacuum induction process. Brochure from Kelsey-Hayes Co.

MATHESON

Compressed Gas Notes

Chlorine in the Research Laboratory

Chlorine has wide application in the research laboratory where it is used in many organic and inorganic reactions. In the following paragraphs we will list some of these uses and offer data and suggestions on handling and regulating chlorine.

Laboratory Reactions

There are many reactions of chlorine with organic compounds in the laboratory, for example: the chlorination of alkane's, cycloalkanes and alkenes. Chlorine adds to olefins and acetylenes.

It is also used for the preparation of halogen derivatives of acetal and for the preparation of chlorohydrins.

In the inorganic field, chlorine reacts with sodium cyanide to give cyanogen chloride; it reacts with aqueous sodium hydroxide to form sodium hypochlorite (useful for the preparation of chlorohydrins and for monochloramine); it is used for preparing vanadium oxychloride by reduction of vanadium pentoxide and subsequent chlorination of the lower oxide; it is used for preparing iodine monochloride from iodine and chlorine; it is used for the preparation of rhenium pentachloride from rhenium and chlorine, in fact, it reacts with practically all metals.

Chlorine for Laboratory Use

The most convenient and widely used laboratory source is a small cylinder of the liquefied gas as supplied by Matheson. Matheson offers chlorine of 99.85% minimum purity in five cylinder sizes:

Cylinder #1A	150 lbs. net
2	40 lbs. net
3	15 lbs. net
4	5 lbs. net
Lecture Bottle	1 lb. net

While the larger cylinders offer lower cost per pound, the smaller cylinders are usually preferred for laboratory use because they provide a more convenient and easy-to-handle source. The No. 3 and smaller cylinders can be easily carried and handled by a single laboratory worker, without the use of trucks.

The cylinder pressure of chlorine at 70° F. is 84 psig. See the Matheson Compressed Gas Catalog for further data and prices.

Controls and Regulators

Fig. 1

Chlorine can be dispensed as a gas at a definite controlled pressure by the use of Matheson regulator No. 15-660. (see Fig. 1). This regulator has a delivery pressure range of 5-50 psig. and is constructed of materials resistant to corrosion by chlorine. The regulator is equipped with a monel needle valve for sensitive flow control. A monel check valve is recommended to prevent foreign materials from being sucked back into the regulator.

Manual monel needle valves for direct attachment to the cylinder valve are also available to dispense either liquid or gaseous chlorine from a cylinder.

The Matheson Company, Inc. also offers a valve, our No. 940-AL, Fig. 2, of Aluminum-Silicon-Bronze body with Teflon packing that is corrosion-resistant and exhibits excellent metering characteristics. The threads on the stem are placed above the packing out of the chlorine stream to insure smooth action. This valve provides very sensitive flow control due to its construction. A panel mounting bonnet is also available at a slight extra charge.

Matheson is able to provide equipment for the complete laboratory control of chlorine as well as other corrosive gases. Our current catalog gives specifications and price information.

Matheson knows how to handle chlorine in the laboratory. Our Sales Engineering Department will be delighted to recommend methods suitable for the handling of chlorine.

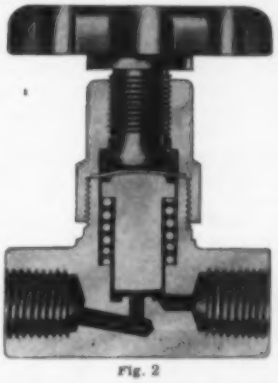


Fig. 2

Write for Catalog and Bulletin

Mail the coupon for a copy of the Matheson Chlorine Bulletin giving detailed specifications on this gas. Every laboratory should have a copy of the Matheson Compressed Gas Catalog, listing 85 compressed gases, special mixtures, recommended controls and gas handling equipment.

The Matheson Company, Inc., P.O. Box 85, E. Rutherford, N.J.

Please send the following:

☐ Matheson Compressed Gas Catalog

☐ Chlorine Specifications and Properties

Name _____

Firm _____

Address _____

City _____ State _____

The Matheson Company, Inc.

Compressed Gases and Regulators

East Rutherford, N. J.; Joliet, Ill.; Newark, Calif.

For more information, turn to Data Service card, circle No. 126

CEP'S DATA SERVICE—Subject guide to free technical literature

CIRCLE CORRESPONDING NUMBERS ON DATA SERVICE CARD

EQUIPMENT *from page 108*

316 Equipment, tableting. New 8-page Catalog AC-61 covering complete line of pharmaceutical and tableting equipment from Arthur Colton Co.

317 Equipment, ventilating, plastic. New Bulletin from Heil Process Equip. Corp. describes rigid vinyl and reinforced plastic hoods, ducts, fittings; includes sizes, specifications and chemical resistance data.

318 Feeder, pressure. Information for twin, counter-rotating, intermeshing screw type pressure feeder which increases capacity of screw presses from Bauer Bros. Co.

319 Feeders, vibrating. New 12-page Book 2869 describes complete line of motorized counter-weight vibrating feeders from Link-Belt Co.

320 Feeders, vibratory. Thirty-two page Catalog gives description, data, specifications, for complete line of electromagnetically vibrated feeders from Syntron Co.

321 Filter Plates, Frames. New polyester plates and frames for greater chemical resistance in filtering processes described in Data Sheet from T. Shriver & Co., Inc.

322 Filters. Catalog describes line of filtration equipment for processing chemicals, gases, oils, and water. Data from Commercial Filters Corp.

323 Filters, air. Bulletin No. 207 describing construction, application of permanent washable unit air filters from American Air Filter Co.

324 Filters, membrane, plastic. Booklet from Gelman Instrument Co. describes new plastic membrane filter material for removing sub-micron particles from fluids and gases.

325 Filters, stainless steel. Literature from Micro Metallic Div. of Pall Corp. gives specifications and properties of porous stainless steel filters.

326 Gages, welded pad. Data from Jerguson Gage & Valve Co. gives features and specifications for liquid level gages which can be welded directly to process equipment.

327 Heat Exchanger. Revised 15-page Catalog from Young Radiator Co. presents data on copper base alloy, steel, and stainless steel fixed tube bundle heat exchangers; includes oil viscosity graph, pressure ratings, and selection tables.

328 Heat Exchangers. Twenty-page Bulletin from Struthers Wells Corp. presents mechanical, thermal design data for quick selection of standard heat exchangers. Practical exchanger calculation and data included.

329 Heaters. Information for new prepackaged fired heaters for easier and more economical installation is available from Brown Fintube Co.

330 Hose, accessories. New 37-page Industrial Catalog No. 204 from Aeroquip Corp. contains complete specifications for hose, fittings, self-sealing couplings. Also includes hose selector chart for variety of chemical agents.

331 Indicators, material level. Information from Fuller Co. describes indicators used to show levels of pulverized or granular materials in process equipment.

332 Instrument, atmospheric contaminants. Details for measurement of traces of any gases or vapors that will ionize in water from Industrial Instruments, Inc.

333 Instrumentation, nuclear. New 50-page Catalog F from Tracerlab contains description of nuclear instrumentation and accessories.

334 Instruments, radiation. Booklet describes dosimeters and pocket changers, electrometers for charging and reading, analysis kits for radiation measurements. Info. from Landsverk Electrometer Co.

335 Joints, expansion. Information available for hinged type expansion joint for piping systems to 72 in. Data from Zallea Brothers.

336 Meter, rotary gas. Dimensions and capacity ratings for small rotary-type positive displacement gas meter for line mounting are available from Roots-Connersville.

337 Mixer, hydraulic. Details from Stevenson Co. describes turbine impeller on mixer with hydraulic device for raising and lowering impeller.

338 Mixer Settler Unit. Design Study Bulletin No. M7-F65 discusses compact mixer-settler unit used in solvent extraction processes in uranium mills. Data from Denver Equipment Co.

339 Pipe, epoxy. Data describing fiber glass reinforced epoxy pipe and fittings for corrosive service are available from Ed Conley Plastic Corp.

340 Pulleys, variable speed. New 24-page Technical Catalog includes selection, operating data, ratings, dimensions, applications for pulleys and related equipment. Info. from Lovejoy Flexible Coupling Co.

341 Pumps. Technical Bulletin gives applications of sealless "canned" pumps for leakproof pumping in the nuclear field. Data from Chempump Division, Fostoria Corp.

MATERIALS *from page 108*

379 Plastics. New 56-page 1960 plastics Purchasing Guide and Catalog from Almac Plastics, Inc. lists plexiglas, acetates, nylon, Teflon, polyethylene, Kel-F, etc.

380 Plastics, industrial. New 16-page Booklet from Polymer Corp. outlines properties, applications for Polypenco nylon, Fluorosint TFE base resin, Nylaflow nylon tubing, hose and other new industrial plastics.

381 Polyester Resin. Data and chart showing resistance of "Hetron 72" to glacial acetic acid at 30-35°C from Durez Plastics Div. of Hooker Chemical.

382 Polyethylene, paper coating. Data for new high-density polyethylene extrusion coating compound for reducing costs of coatings in paper packaging industry from Union Carbide Plastics.

383 Polymer. Technical data for new, fatty acid emulsified, cold type SBR copolymer for use in rubber processing now available from Goodrich-Gulf Chemicals, Inc.

384 Polypropylene. New Brochure describes properties and applications of polypropylene. Data from Catalin Corporation of America.

385 Polypropylene. Four new Technical Data Bulletins on general purpose extrusion and injection molding polypropylene polymer from AviSun Corp.

386 Polypropylene. Information for complete line of polypropylene block for elevated temperatures, rigid construction service, nuclear shielding. American Agile Corp.

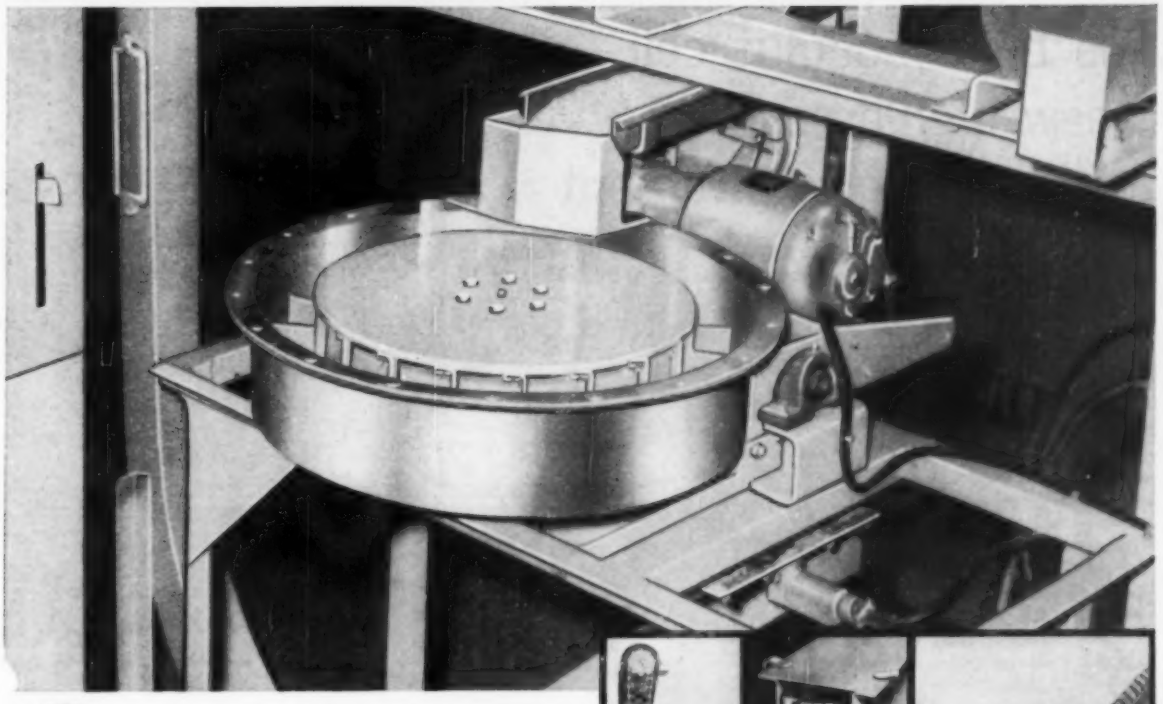
387 Radiochemicals. New 46-page Catalog includes prices, licensing information, purity methods for carbon-14 labeled compounds from Research Specialities Co.

388 Resins, ion exchange. Catalog gives data for anion, cation, and mixed bed ion exchange resins; special resins as chelating, carboxylic, polyamine; and ion-exchange celluloses. Info. from BIO-RAD Labs.

A.I.Ch.E. Membership

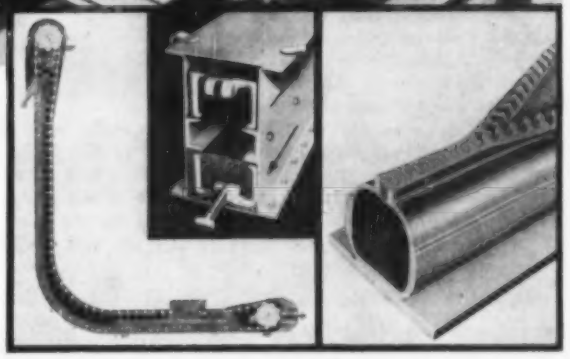
Brochure—"Know Your Institute"—tells objective aim and benefits to chemical engineers who join this nation-wide organization, includes membership blank. Circle number 600 on Data Post Card.

STEPHENS-ADAMSON



S-A CONTINUOUS WEIGHER PROVIDES EXTREME ACCURACY!

The STEPHENS-ADAMSON Continuous Weigher weighs material continuously while in motion with extreme accuracy. Material entrance and exit points are in line with pivot axis of weigher providing for easy installation within existent processing operations and completely eliminating all discharge terminal errors. The unit handles hot material with equal accuracy. Minimum headroom is required. The weigher can be adapted with control equipment for accurate gravimetric feeding without requiring extensive plant alterations. STEPHENS-ADAMSON engineers will be happy to work with you on automating your processing operations.



S-A REDLER CONVEYOR

Skeleton flights, linked together and moving through totally enclosed casings, induce the mass movement of powdered, granular or flaky bulk materials in any direction. Gentle conveying action and sealed casings mean maximum protection for materials handled. Redler units combined with Continuous Weigher offer automatic operation. Request Bulletin 358.

S-A ZIPPER CONVEYOR

Literally a moving, material-carrying conduct, the zipper closed belt, conveyor-elevator is capable of transporting bulk materials in any plane, to considerable heights and around obstructions. Bulk materials are conveyed free of breakage, agitation or segregation within the sealed and dustight belt. The zipper combined with Continuous Weigher is ideal for automatic feeding operations. Request Bulletin 349.

WRITE FOR BULLETIN 958

S-A

ENGINEERED BULK HANDLING SYSTEMS

SPEEDWALK® PASSENGER CONVEYORS

SINDECO® BEARINGS & ROD ENDS

ENGINEERING DIVISION

STEPHENS-ADAMSON MFG. CO.

GENERAL OFFICE & MAIN PLANT, 57 RIDGEWAY AVENUE, AURORA, ILLINOIS

PLANTS LOCATED IN: LOS ANGELES, CALIFORNIA • CLARKSDALE, MISSISSIPPI BELLEVILLE, ONTARIO

For more information, turn to Data Service card, circle No. 84

industrial news

D. H. Newhall and L. H. Abbot, *Harwood Engineering, Walpole, Mass.*

The bulk modulus cell —new high-pressure measurement instrument

Rugged and reliable device expcted to find wide application in industrial and research operations in the 0-50,000 and 0-200,000 lb./sq. in. ranges.

The bulk modulus cell (Figure 1) consists essentially of a hollow cylindrical steel probe, closed at its inner end, introduced into a thick-walled steel cylinder, the cell-body, which is connected hydraulically to the high pressure system. The probe is held in place by a threaded retainer which also serves to compress a conventional packing between shoulders on the cell-body and on the probe. A stem projects from the inner end one inch beyond the outer end of the probe proper. A clearance of 1/64 in. between the stem and the wall of the probe assures freedom of motion.

When the active part of the probe, from the shoulder inward, is subjected to the hydrostatic pressure of the system it contracts isotropically, and its contraction is measured by the motion of the stem, unrestrained except at its two ends, with respect to the outer end of the probe.

To a first approximation, the active part of the probe may be treated as an isotropic solid. An average value for the bulk modulus of steel (defined as $(p_2-p_1)/(v_1-v_2)/v_1$ where p_1, p_2 and v_1, v_2 are the initial and final pressure and volume respectively) is 23.3×10^6 lb./sq. in. and its reciprocal, the compressibility, is 4.48×10^{-6} lbs.$^{-1}$ in.^{2}. Since the deformation in any single direction is one third the compressibility, we can compute the axial contraction of the probe, that is, the stem motion, knowing the effective length and the applied pressure. Thus, with one hundred thousand pounds per square inch applied to a two-inch probe, we get a contraction of $\frac{1}{3} \times 4.48 \times 10^{-6} \times 100{,}000 \times 2 = 0.033$ in., which is large enough to be measured precisely in any of several ways.

Actually, the probe, as presently proportioned, is suitable for ranges from 0-50,000 to 0-200,000 lb./sq. in. While it would be a simple matter to modify the probe, by lengthening it or choosing a material of lower bulk modulus, so as to be useful at lower pressures, existing instrumentation seems to be adequate in that region. Development of the cell for use at higher pressures is contemplated, though as yet no industrial processes except diamond synthesis are known

continued on page 115

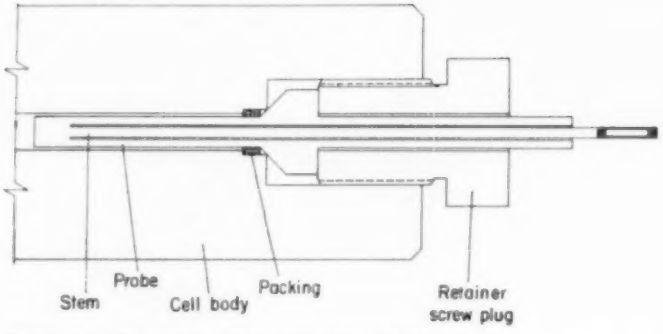


Figure 2. The transmitter—operating details.

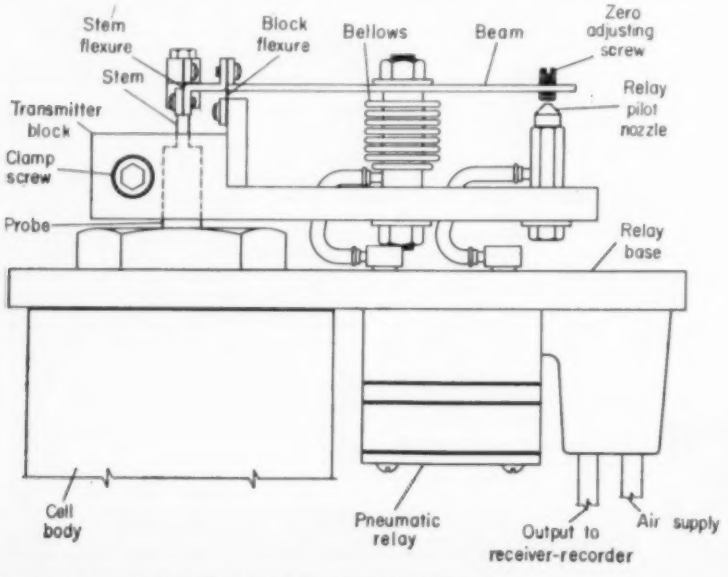
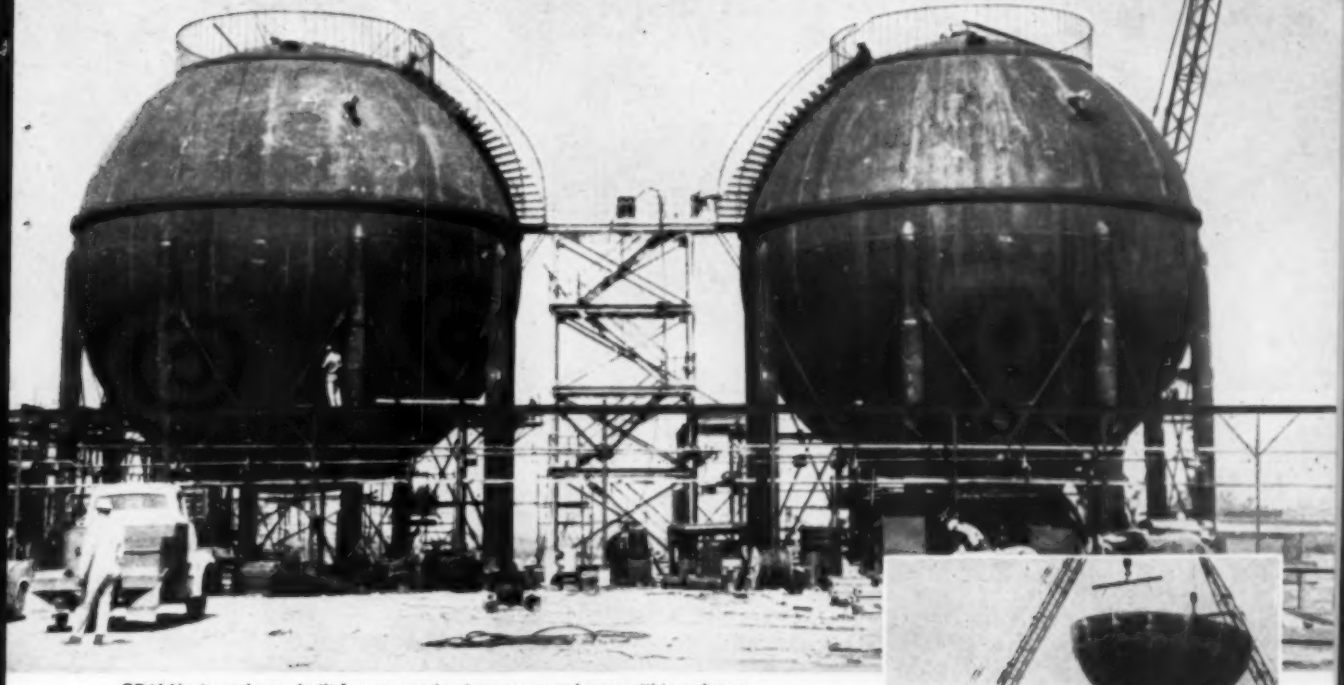


Figure 1. The bulk modulus cell—schematic diagram.

HOW TO STORE LIQUIDS AT -320°F.



CB&I Hortonspheres built for cryogenic storage are spheres within spheres.

CB&I-built HORTONSPHERES® do it for Linde at Pittsburg, California

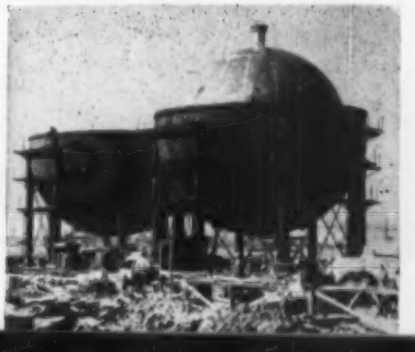
CB&I engineered, fabricated and erected these special Hortonspheres for Linde's new plant at Pittsburg, California, using Linde-approved designs. One is used to store liquid oxygen at —297° F. The other will store liquid nitrogen at —320° F.

Their construction is unusual . . . each structure is actually a sphere within a sphere. A specially designed rod support system cradles the 38'9" diam. aluminum inner sphere within the 46'9" diam. carbon steel outer shell. Heat transfer to the inner sphere is minimized by powdered insulation placed between the inner and outer shell.

Cryogenic storage calls for vessels of special design . . . and the know-how to build them. Linde Company used this know-how from CB&I's seven decades of craftsmanship in steel. So can your company. Write for further details.

Photo taken during erection shows cranes setting section of aluminum inner sphere.

Above and below: Experienced CB&I erection crews make tough jobs look easy.



CSICB

CHICAGO BRIDGE & IRON COMPANY

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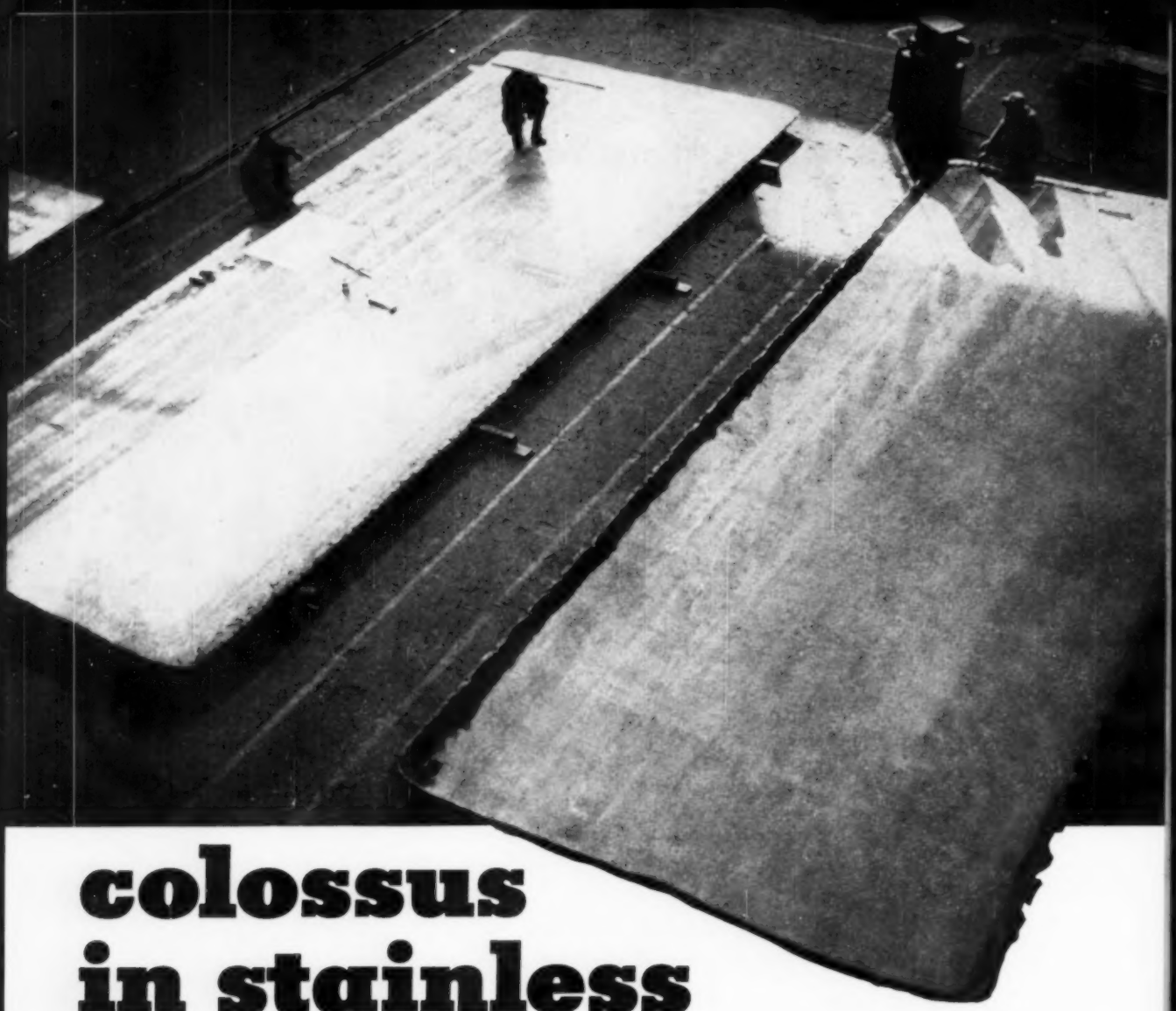
CHICAGO 4, ILLINOIS

OFFICES AND SUBSIDIARIES IN PRINCIPAL CITIES THROUGHOUT THE WORLD

For more information, turn to Data Service card, circle No. 56



colossus in stainless

...world's largest stainless steel plates ready for processing at Carlson

SOMETIMES Carlson service is a cooperative venture that gets practically impossible jobs done. The processing and finishing of these, the world's largest stainless steel plates, is an example of such teamwork.

As this was a "first time" job, the most careful planning and coordination had to be exercised. Oversize ingot molds and a 70-ton capacity furnace had to be used. It took the country's largest plate mill to roll the ingots to slabs, the slabs to plates. The finished plates, cut-to-shape by Carlson specialists, met every customer requirement.

These huge plates, of Type 304 stainless steel, were made to Specification A-240 Grade S (ASTM A240-T). Each plate weighed over 49,000 pounds; one measured 461" x 179" x 2"; the other 451" x 184" x 2". Destined for a nuclear application, these plates were flame-cut and abrasive-cut to make two half-circles. The entire order totaled nearly 100,000 pounds.

Cooperation made this "colossus" a success—cooperation under the knowing eyes of Carlson specialists. This same team is ready to work on your order. We invite you to write, wire or phone for further information.

G.O.CARLSON Inc.

Stainless Steels Exclusively

124 Marshalton Road
THORNDALE, PENNSYLVANIA
District Sales Offices in Principal Cities

PLATES • PLATE PRODUCTS • HEADS • RINGS • CIRCLES • FLANGES • FORGINGS • BARS and SHEETS (No. 1 Finish)

For more information, turn to Data Service card, circle No. 28

High pressure

from page 112

to operate above two hundred thousand pounds per square inch.

Transmitter

Measurement of the motion of the stem, either by electromagnetic or by capacitive effects applied to an alternating-current bridge, was considered. For greater overall convenience, however, a pneumatic transmitter developed by the Foxboro Co. (Figure 2) appears to have important advantages. This is used in conjunction with a Foxboro pneumatic receiver which may be a simple indicator, a chart recorder, or a recording controller.

The beam of the transmitter is a cantilever held in equilibrium by the downward-acting restraint of the block flexure (made of spring steel), and by the upward force exerted by the stem, the bellows, and the air jet from the relay pilot nozzle. Since the pressure within the air jet is but a fraction of that within the bellows, and the cross-sectional area of the bellows is a hundred or more times larger, the effect of the jet on the beam is negligible. The transmitter operates on an air supply at 20 lb./sq. in. gauge, which is modulated to deliver 3 pounds to the receiver when the probe is at atmospheric pressure, and 15 when the probe is at full range.

As pressure is applied to the probe, it contracts, and the stem moves upward, causing the beam to pivot at the block flexure and compress the bellows. The deflection of the beam also restricts the air space above the relay pilot nozzle; this raises the air pressure within the bellows until equilibrium is established again. The change in the bellows pressure is proportional to the system pressure felt by the probe. Calibration is accomplished by loosening the nuts and moving the bellows along the beam, increasing the moment arm in order to reduce the transmitted air pressure.

The receiver is a standard instrument which has been widely used to measure pneumatically such effects as flow, temperature, liquid level, pressure, and humidity. It operates well when the air pressure is transmitted to it from the transmitter bellows through as much as a thousand feet of tubing; a shorter line increases the speed of response.

Application limits

Table 1 sets forth a comparison of

continued on page 116

BETTER
PARTICLE
SIZE
CONTROL
Grinding operations by the centrifugal IMPACT MILL result in a much lower percentage of fines or oversizes through absolute control of impact velocity. Particle size reductions can be extremely well controlled within a narrow band even down to sub-sieve ranges.
TYPICAL APPLICATIONS
Agricultural insecticides
Flour
Household detergents
Cement
Pelletizing of plastic resins
Series 14
ControMil.
WHAT CAN IMPACT DO FOR YOU?
Tell us your problem and your specifications.
The Entoleter Laboratories will run a test sample free.
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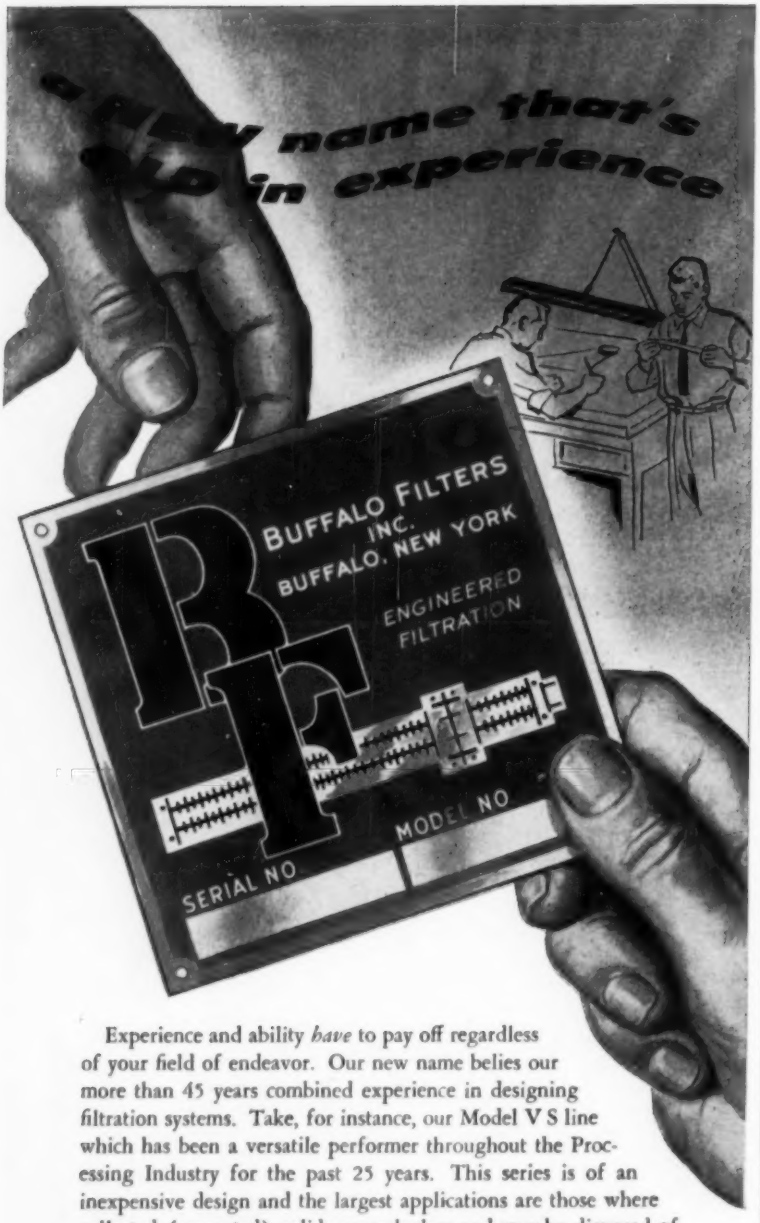
For more information, turn to Data Service card, circle No. 101



Experience and ability *have* to pay off regardless of your field of endeavor. Our new name belies our more than 45 years combined experience in designing filtration systems. Take, for instance, our Model V S line which has been a versatile performer throughout the Processing Industry for the past 25 years. This series is of an inexpensive design and the largest applications are those where collected (separated) solids are valueless and may be disposed of by means of sluicing. Among the many features are high flow capacity leaves with special drain backing, high sluicing efficiency and rapid opening cake door for easy removal of semi-dry solids. Write for literature on our V S line or, for further information, contact Edward A. Ulrich, President.

Write for Bulletin SM-1100 or Phone Victoria 5455

BUFFALO FILTERS, INC.
1807 ELMWOOD AVE. BUFFALO 7, N. Y.

For more information, turn to Data Service card, circle No. 60

High pressure

from page 115

the bulk modulus cell in range and accuracy with the other pressure measuring instruments applicable in the same field.

The bulk modulus cell should find its most important applications where comparatively rapid pressure changes or viscous media would be unfavorable to manganin cells; for pressures in the ranges between 0-50,000 and 0-200,000 lb./sq. in. where moderate accuracy and rather fast instrument response are desired.

Table 1.

Instrument Type	Available ranges Pounds per sq. inch Minimum	Maximum	Accuracy per cent of Full Scale
Bourdon	—	0-100,000	0.2 to 5*
Strain Gage	—	0- 50,000	0.25
Long Helical	—	0- 80,000	0.5
Bulk Modulus	0-50,000	0-200,000	1.0
Manganin	0-50,000	0-425,000	0.1 to 0.5**

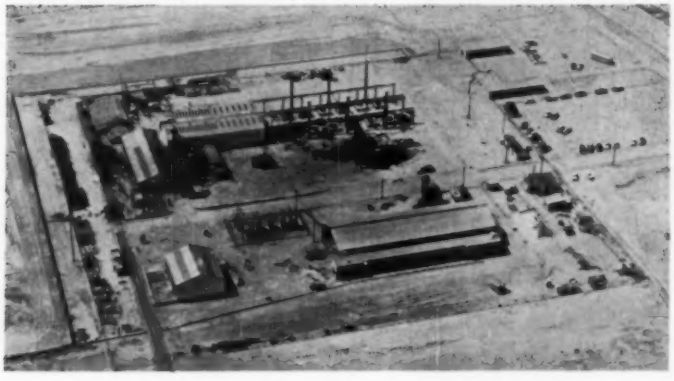
* *Depending on range and manufacturer.*
** *Depending upon instrumentation.*

Closest competition for the bulk modulus cell is provided by the manganin gauge. For pressures up to 425,000 lb./sq. in., or for accuracy of the order of one tenth percent of full scale, the latter is indicated.

At ranges below 75,000 lb./sq. in., choice between a bulk modulus cell, a Bourdon gauge, and a strain gauge will depend mostly on convenience, cost, accuracy, and hazard. The Bourdon, as an indicator, is the simplest. It is frequently installed directly on the system, but, by use of a capillary, it can be located at a distance. It must be borne in mind, however, that when installed on a panel in this manner full pressure is brought to the panel. The bulk modulus cell and the strain gauge are both characteristically remote-reading, though, in the case of the former, it is advantageous to make the transmission line short. The bulk modulus cell is distinctly superior, especially to the conventional Bourdon and, to a lesser degree, to the strain gauge and long helical in the matter of hazard. The probe, being subjected to hydrostatic compression only, is not subject at rated pressure to fatigue which would result from repeated excessive strains, and the transmitting air pressure is completely innocuous.

continued on page 118

GLC EXPANDS PRODUCTION WITH GRAPHITE PLANT SERVING WESTERN STATES



The GLC graphite plant at Antelope Valley, California.

We are glad to inform the electrometallurgical and electrochemical industries in the Western States area that we recently acquired the plant and physical assets of Crescent Carbon Corporation in California.

Carbon and graphite users in the Western States and those overseas in the Pacific area will shortly have a greatly improved source of supply at their command.

Plans now under way at the GLC graphite plant, Antelope Valley, California, call for a substantially increased inventory of electrodes, anodes and mold stock, not only in tonnage but in a variety of shapes and sizes as well. Customers can look forward to faster service on their shipments and to closer cooperation in solving their technical problems.

Technicians from our plants at Niagara Falls, N.Y. and Morganton, N.C. are establishing the most modern production techniques at the Antelope Valley plant, so that its products will meet established GLC standards of quality and uniformity.

As these forward steps are taken, we hope to have the privilege of widening the scope of our service to customers, old and new.

PRODUCTS ELECTRODE GLC DIVISION YOU CAN TRUST

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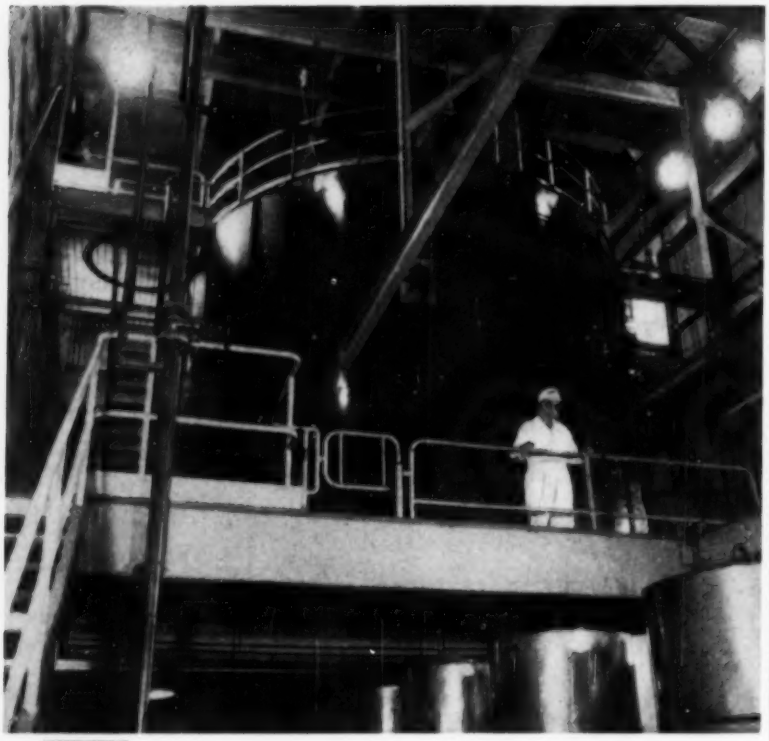
For more information, turn to Data Service card, circle No. 35



NERCO NIRO

SPRAY DRYER SOLVES DIFFICULT DRYING PROBLEM AT DOW

An agricultural chemical containing the sodium salt of an organic acid presented a real drying challenge to the Dow Chemical Company.

Here was a product extremely heat sensitive and highly hygroscopic, yet requiring drying to a moisture content of less than 1%. Ordinary drying processes resulted in chemical decomposition.

Development work in the NERCO-NIRO spray dryer laboratories by a team of scientists and engineers from Dow and Nichols resulted in design of the spray dryer pictured above, which produces more than one ton per hour.

This NERCO-NIRO spray dryer not only accomplishes "Gentle-ized" drying, but uses drying air temperatures of 500°-600°F. with corresponding high thermal efficiency.

For solution to your drying problem, contact: NERCO NIRO

Nerco-Niro Spray Dryer Div.

NICHOLS ENGINEERING & RESEARCH CORPORATION

70 Pine St., New York 5, N. Y.

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Montreal

For more information, turn to Data Service card, circle No. 15

High pressure

from page 116

The cell body has no limitations on its proportions, imposed by the functioning of the probe, hence can be built to maximum strength and fatigue resistance. This is in marked contrast to those operating elements whose signal depends on internal pressure. There are distinct advantages, also, in pneumatic transmission; in an explosive atmosphere it presents no danger from sparks, and the signal is not subject to the disturbing influence of stray magnetic fields.

Rights to the new nitrile fiber, Darvan, developed by B. F. Goodrich, and just purchased by Celanese, are expected to further diversify the company's line of synthetic fibers. Celanese acquires the patents, trademark, technical know-how, and world rights for production and marketing of the fiber. Goodrich retains rights outside the textile fibers field, including plastics applications. They will operate the Development Center in Avon Lake, Ohio, where Darvan is now being produced, until Celanese starts production with its own facilities.

W. R. Grace has acquired a substantial interest in the Puerto Rican firm, Gonzalez Chemical Industries. Under a re-organization, the agricultural chemical company, which operates an ammonia, sulfuric acid, and ammonium nitrate plant in Guanica, changed its name to Caribe Nitrogen Corporation.

An expansion in chlorine-caustic at the Stauffer Chemical Henderson, Nevada, plant will increase output of the unit by 25 percent. The expansion, made to supply increasing western demand for chlorine, is scheduled for completion in May.

One of the country's largest producers of pyridine, Reilly Tar & Chemical, is doubling the capacity of its synthetic pyridine plant. Completion is scheduled for late 1960.

To increase production capacity of caustic soda, caustic potash and chlorine at its Niagara Falls, N. Y. plant, Hooker Chemical plans to invest about $10 million in a new installation of Hoechst-Uhde mercury-type electrolytic cells. The first phase of a four-step electrolytic cell expansion program over the next few years, the installation should be completed by mid-1961.

For more information, circle No. 145

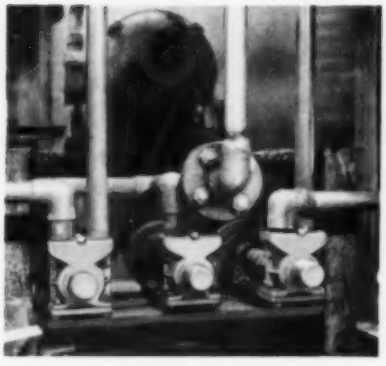
ECO ENGINEERING NEWS

the big name in small pumps for the process industries

Pumping Notes

•

Mallinckrodt Nuclear Corp. Gives ALL-CHEM Pumps Tough Job . . .



The battery of three ALL-CHEM Pumps shown above, driven by a single motor, is being used on a continuous, countercurrent extraction system. They are pumping tri-butyl-phosphate, kerosene and 3N nitric acid.

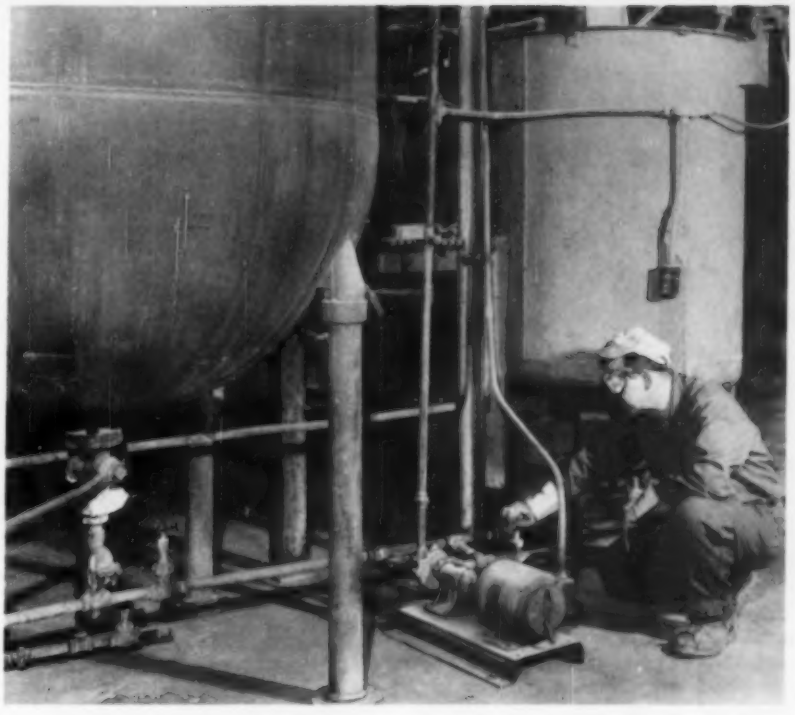
These ALL-CHEM Pumps are 304 stainless steel with Teflon† impellers and bearings and special Teflon and Halocarbon packing.

Though the nitric acid is extremely corrosive and the tri-butyl-phosphate is extremely hard to contain—these pumps and their packing are performing well on the job.

Eco Pumps Shown at Swiss Exposition

The ILMAC Exhibit recently held in Basle, Switzerland, is one of the most important held in Europe, pertaining to chemical equipment.

This official Eco Exhibit was conducted by our Swiss distributor, Mr. Henry C. Iseli.



CENTRI-CHEM Pump Provides Satisfaction to Largest Producer of Tin Chemicals

Metal and Thermit Corporation, Carteret, New Jersey, not only is the largest producer of tin chemicals in America—such chemicals as stannic chloride, stannous oxide, bismuth and barium stannates—but they also are engaged in the largest de-tinning operation from tin plate scrap in the country.

In these processing operations, it is obvious that some very difficult acids, caustics and slurries must be pumped.

In 1956 this company decided to try an Eco PTA-4 CENTRI-CHEM Pump for transfer of bismuth nitrate in excess nitric acid at ambient temperatures. This pump was also required to pump caustic solutions on occasions.

The CENTRI-CHEM Pump has now been continuously employed for three years on intermittent pumping service giving completely satisfactory operation. During these three years, only one basic repair has been required, which was the replacement of the mechanical seal.

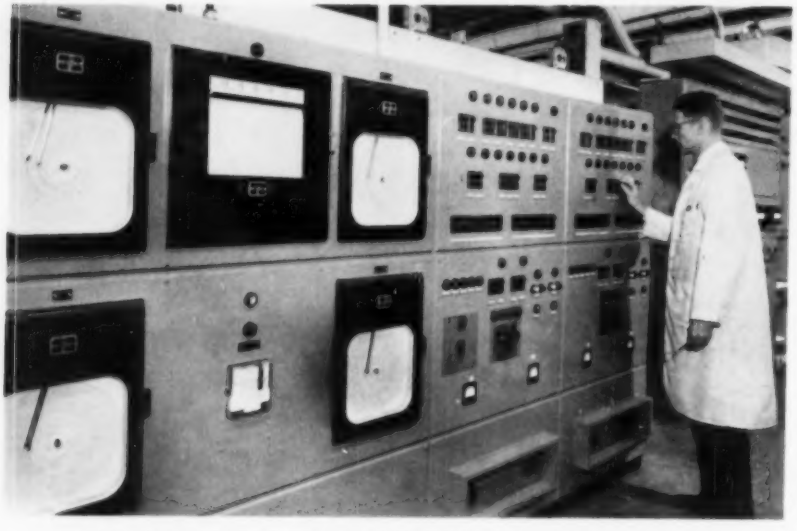
Eco CENTRI-CHEM Pumps feature Type 20 stainless steel throughout—casings, shafts and impellers—which is the reason why they meet such a wide range of corrosive service.

The mechanical seal used in CENTRI-CHEM Pumps has proven serviceable and leakproof within temperature ranges from minus 150°F to plus 450°F. It is simply constructed and easily maintained.

Seal components to meet various exposures include Teflon and ceramic, carbon and ceramic, and carbon and Type 20 Stainless or Stellite*. These components are dimensionally interchangeable.

*Union Carbide Trademark. †du Pont Trademark.

Eco Pumps Help Film Finisher Save $12,000 Worth of Silver, Annually



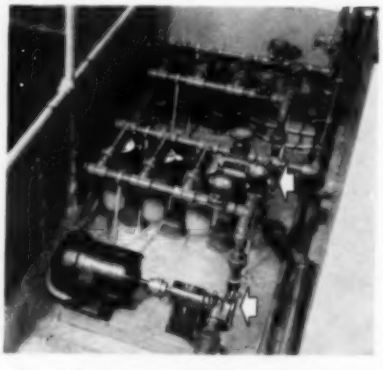
Control Engineer Spencer B. Fulweiler at one of the instrument panels from which all Film Finishing operations in this precision laboratory are controlled.

The Berkey Photo Service, Inc., with offices in New York, Boston, New Haven, Chicago and Detroit, is the largest independent color and black-and-white film finishing company in the world. More than 350 people are employed in the New York laboratory, alone.

For greatest efficiency this huge film finishing laboratory has been completely automated to insure exceptional quality control and maximum economy of operation.

For the reclamation of excess silver from the fixers, Berkey engineers, last May, installed a fixer recirculating system utilizing silver recovery cells and three Eco CENTRI-CHEM Pumps.

Two of these pumps have been in continuous service, 24 hours of the day, seven days of the week, since May 1959 without a single maintenance problem. The third pump is installed as a stand-by.



Two of the three Eco CENTRI-CHEM Pumps which recirculate the fixer through silver recovery cells.

Engineer Fulweiler who installed these pumps states that this silver recovery system is saving at the rate of $12,000.00 worth of silver annually.

ECO Products for Handling Corrosive and Hazardous Processing Fluids

ALL-CHEM® Rotary Pumps
MINILAB® Rotary Pumps
GEARCHEM® Gear Pumps
CENTRI-CHEM® Centrifugal Pumps
PUMPMOBILE® Portable Pumping Units
GEAR-VAC® Valves
CHEMICAL DISPENSING VALVES
Factory Mutual Approved

Ask for literature on any or all of these ECO Products

ECO ENGINEERING NEWS

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The "Who Pumps What With Eco" Department

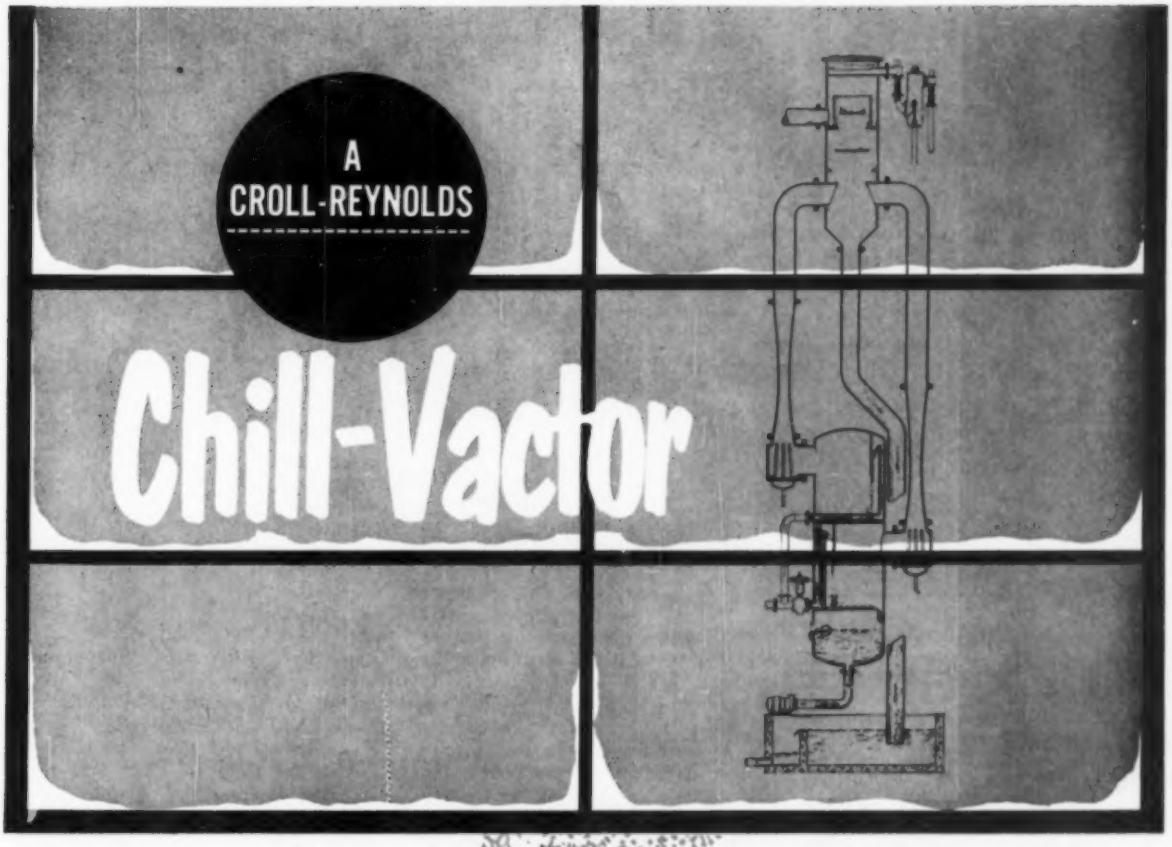
Example: Gesellschaft fur Angewaudte Chemie A. G., Baden, Switzerland, has operated an Eco ALL-CHEM Pump, 316 stainless steel construction with Teflon impellers, for the handling of phosphoric acid at room temperature, for two years.

During this period, the pump has handled over 25 metric tons of this acid. The only repair required was one replacement of the Teflon impellers.

Example: Sylvania Corning Nuclear Corporation, Hicksville, L.I., New York, have repeatedly purchased Eco ALL-CHEM Pumps in 316 stainless steel with Teflon impellers, bearings and packing for handling hot nitric acid solutions at temperatures near 180°F.

Example: Radio Corporation of America, Lancaster, Pennsylvania, have purchased Eco Pumps for a number of years. These include both ALL-CHEM and GEARCHEM types for a variety of services covering caustics, acids, etc.

Example: Chesebrough-Ponds, Inc., Clinton, Connecticut, well known for Vaseline products and cosmetics, have operated a number of pedestal mounted CENTRI-CHEM Pumps as well as 316 stainless steel ALL-CHEM Pumps for several years. Media pumped range from lotions to solvents to emulsions, etc.



Comes Nearest to Natural Refrigeration

Nature produces refrigeration (snow, sleet, and hail) indirectly by change of atmospheric pressure to bring warm water vapor in contact with cold air.

NO CHEMICAL REFRIGERANT OR ABSORBENT TO LEAK, CORRODE OR CRYSTALLIZE

In each case, water is its own refrigerant or cold air serves the purpose. Jet vacuum refrigeration comes nearest to this natural refrigeration.

As a method of industrial refrigeration, jet vacuum refrigeration is thoroughly established and is successful in many hundreds of industrial plants in capacities varying from a few tons to 4500 tons.

The unit sketched can be placed outdoors and operated continuously or intermittently in any climate. The equipment adapts itself readily to automatic control or is very easy to control manually. The unit is self-supporting. There are no moving parts, no noise, no vibration. The maintenance and supervision required are negligible.

While most vacuum installations are used to cool water, vacuum cooling is particularly efficient for cooling chemical solutions. Instead of the usual expensive heat transfer surface, only simple corrosion-resistant vessels are needed. Some process plants have dozens of separate units totaling thousands of tons of refrigeration just for the purpose of cooling chemical solutions. Their record of savings is remarkable.

There are many other applications, too. Fresh vegetables and other moist solids are readily cooled by jet vacuum refrigeration. By adding a heat exchanger bundle inside the vacuum chamber, gases can be cooled without circulating any liquid. In some cases, the automatic de-aerating effect of vacuum cooling is important.

Many installations of old style mechanical refrigeration could be replaced profitably with vacuum refrigeration, which costs much less to buy and somewhat less to operate.

All inquiries will be given careful engineering study without obligation.

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For more information, turn to Data Service card, circle No. 49

Photo courtesy Coliseum Exhibition Corp.

Nuclear week in New York

Coliseum will be host to 1960 Nuclear Congress April 4-7.

SEVEN MAJOR AREAS of the nuclear field will come under scrutiny at the up-coming 1960 Nuclear Congress to be held at New York City's Coliseum, April 4-7. Fifty-one technical papers will be devoted to reactors, reactor design, materials and components, nuclear standards, isotopes, and radiation processing.

Of vital interest to the chemical engineering fraternity will be the Wednesday morning session on *Isotope Application*. Papers of particular practical interest are *Industrial Radioisotope Applications Development Sponsored by AEC* (Paul G. Aebersold, AEC), and *Applications of Nuclear Science in the Producing Branch of the Petroleum Industry* (M. Williams, Humble Oil & Refining). Also worthy of special note from the chemical engineer's standpoint will be R. J. Klotzbach's Tuesday morning paper on *Uranium-Thorium Reprocessing; Cost Outlook for Commerical Operation* (Session on Fuel Technology).

Coordinated with the technical sessions at the Congress itself will be the Sixth International Atomic Exposition, the sessions of the Eighth Atomic Energy in Industry Conference, sponsored by the National Industrial Conference Board, and sessions of the Society of Automotive Engineers on nuclear propulsion in aircraft.

All-Congress session

The 1960 Congress will lead off with a general session on Monday morning, at which three papers will be delivered on the theme: *What Will Future Development of Nuclear Energy Demand from Engineers.* Speakers will be: J. R. Menke, Nuclear Development Corp. of America—Outer Space Exploration and The Nuclear Engineer; W. H. Zinn, Combustion Engineering—Fuel Utilization in Future Atomic Power Plants; W. K. Davis, Bechtel—Engineering Requirements for the Future.

Coordinated by Engineers Joint Council, the Congress is sponsored by twenty-eight engineering, scientific and industrial organizations. Headquarters hotel will be the Statler Hilton in New York, which will also be the scene of the All-Congress Banquet on Wednesday evening.

The full program for the technical sessions, as well as a listing of the exhibitors at the Exposition (with floor plan) is given on the following pages. #

Three-Day Schedule of Technical Sessions

MONDAY, APRIL 4

9:30 a.m.

ALL CONGRESS SESSION—WHAT WILL FUTURE DEVELOPMENT OF NUCLEAR ENERGY DEMAND FROM ENGINEERS.
Chairman: John R. Menke, Nuclear Development Corporation of America

Outer Space Exploration and The Nuclear Engineer, John Simpson, Atomic Power Dept., Westinghouse Electric Corp.

Fuel Utilization in Future Atomic Power Plants, Walter H. Zinn, Combustion Engineering

Engineering Requirements for The Future, W. Kenneth Davis, Bechtel Corp.

2:00 p.m.

MATERIALS AND COMPONENTS—SESSION I—METAL, CERAMIC, ORGANIC MATERIALS.
Chairman: Bruce W. Dunnington, Battelle Memorial Institute

Effect of Irradiation on Tensile Properties of High-Temperature Steel and Non-Ferrous Alloys, Sam Bartz, Phillips Petroleum

Experience in Use of Organic Coolant in Nuclear Reactors, S. C. Spencer, W. N. Bley, R. W. Burkhardt, O. O. Haroldsen, Atomics International

Problems in Contamination of Water-Cooled Reactors Using Stainless Steel Components, Dennis Foley, Alco Incorporataed

U. S. Bureau of Mines Research on the Fused Salt Electrorefining of Beryllium, D. H. Baker, Jr., M. M. Wong, R. E. Campbell, Boulder City, Nevada

Preparation of High Purity Thorium by Reduction With Sodium, F. E. Block, P. C. Good, U. S. Bureau of Mines

2:00 p.m.

ENVIRONMENT—SESSION I PLANT CONSTRUCTION AND SITE LOCATION
Chairman: J. Cal Callahan, Morris-Knowles, Inc. Vice Chairman: William C. Siler, Jackson and Moreland, Inc.

Results of 1959 Nuclear Power Containment Tests, Alf Kolflat, Sargent and Lundy

Review of Shippingport Operations—Site Factors, John E. Gray, Coordinator of Atomic Power, Duquesne Light Company

The N. S. Savannah—Progress Report, P. P. Eddy, K. W. Hess, Nuclear Projects Office, GAO

Civil Engineering Aspects of Nuclear Power Plants, R. W. Kupp, J. C. Tourek, Vitro Engineering Co.

continued on page 136

Atomic Exposition will show the latest nuclear industry products and services to what is expected to be the largest attendance thus far.

AMF Atomics, Div. of American Machine & Foundry Co., Greenwich. Conn.
Heavy duty master-slave manipulator, high pressure rack & pinion control rod drive mechanism, also research reactor techniques & reactor servicing equipment. **526-528-530**

A.M.F. Atomics (Canada), Ltd., Port Hope, Ont.
Fuel elements. **501-517, 600-616**

Ad-O-Plastics, Woodbridge, N.J.
Plastic radiation warning signs & safety signs. **641**

Aeroquip Corp., Marman Div., Los Angeles, Calif.
Couplings, clamps, joints & bellows. **524**

Aetna Casualty & Surety Co., Inc., Hartford, Conn.
Insurance against the hazards of radioactive contamination. **548**

Allis-Chalmers Mfg. Co., Milwaukee, Wisc.
C stellarator facility model will show the intricacies of fusion reaction test equipment now under construction, Pathfinder Atomic Power Plant model showing general layout of a plant, and Elk River reactor model showing details of construction within a containment vessel. **212-216**

American Potash & Chemical Corp., Lindsay Chemical Div., New York, N. Y.
Thorium salts, rare earth metals, boron products & cesium & rubidium materials. **506**

Anton Electronic Laboratories, Inc., Brooklyn, N. Y.
Alpha, beta, gamma, & neutron detector tubes, survey meters, rate meter—scaler combination, & radiation detection equipment. **625**

Appareils Gachot, Enghein, France. **221-233, 320-332**

Assembly Products, Chesterland, Ohio.
New AC-DC contact making wattmeter, new continuous reading meter-relay, standard locking contact meter-relays, API panel meters, & complete control packages. **645**

Association Technique Pour la Production et l'Utilisation, Paris, France. **221-233, 320-332**

Atomic Energy of Canada, Ltd., Commercial Products Div., Ottawa, Ont.
Irradiation equipment, radioactive sources. **501-517, 600-616**

Bendix Aviation Corp., South Bend, Ind. **527-529, 531-533, 535**

Bendix Computer Div., Bendix Aviation Corp., Los Angeles, Calif.
Computers, computer accessories, & computing services. **527-529, 531-533, 535**

Bendix Products Div., Bendix Aviation Corp., South Bend, Ind.
Control rod drive mechanism. **527-529, 531-533, 535**

Beryllium Corp., Reading, Pa.
Beryllium metal, beryllium oxide, beryllium copper—raw materials & finished products. **638-640**

Bohna & Co., B. D., Ltd., Vancouver, B. C.
Design & construction of nuclear facilities. **501-517, 600-616**

Brush Beryllium Co., Cleveland, Ohio.
Beryllium metal & beryllium oxide. Particular emphasis will be placed on forms & shapes of these products, which have nuclear applications. **204-206**

Burroughs Corp., ElectroData Div., Pasadena, Calif.
Components of Burroughs 205 & Burroughs 220 computer systems. **239**

Cambridge Filter Corp., Syracuse, N. Y.
Absolute air filters, Aerosolve air filters, Microtain series of filters, combination frames, type "H" hood-filters, & glove-box filters. **325**

Canadian Department of Trade & Commerce, Ottawa, Ont.
Uranium concentrates, reactor fuel elements, radioactive sources & reactor equipment. **501-517, 600-616**

Canadian Engineering (International) Co., Ltd., Montreal, Que.
Consulting engineering. **501-517, 600-616**

Canadian General Electric Co., Ltd., Peterborough, Ont.
Reactors, reactor design, fuel elements. **501-517, 600-616**

Canadian Westinghouse Co., Ltd., Hamilton, Ont.
Reactors, reactor design, loop studies. **501-517, 600-616**

Central Research Lab., Inc., Red Wing, Minn.
Master-slave manipulators & accessories. **621**

Charleston Rubber Co., Charleston, S. C.
Neoprene dry box gloves, RAD-BAR lead loaded dry box gloves. **306**

Cincinnati Div., Bendix Aviation Corp., Cincinnati, Ohio.
Dosimeters, dosimeter charges, microammeters, reactor control rods, reactor controls. **527-529, 531-533, 535**

Combustion Engineering, Inc., New York, N. Y.
Various types of reactors including pressurized water, boiling water, gas cooled, heavy-water-moderated, sodium-cooled, fast breeder, & packaged power units, also special nuclear services. **649-650**

Commissariat a l'Energie Atomique, Paris, France. **221-233, 320-332**

Consolidated Controls Corp., Bethel, Conn.
Pressure & temperature detectors & controls, high temperature pressure transducer, proximity switching through shielding & pressure switches. **534**

Consolidated Denison Mines, Ltd., Toronto, Ont.
Uranium concentrates. **501-517, 600-616**

Consolidated Siphon Supply Co., Inc., New York, N. Y.
Stainless steel tanks & mixers, stainless steel sinks, & special fabrications from stainless steel. **308**

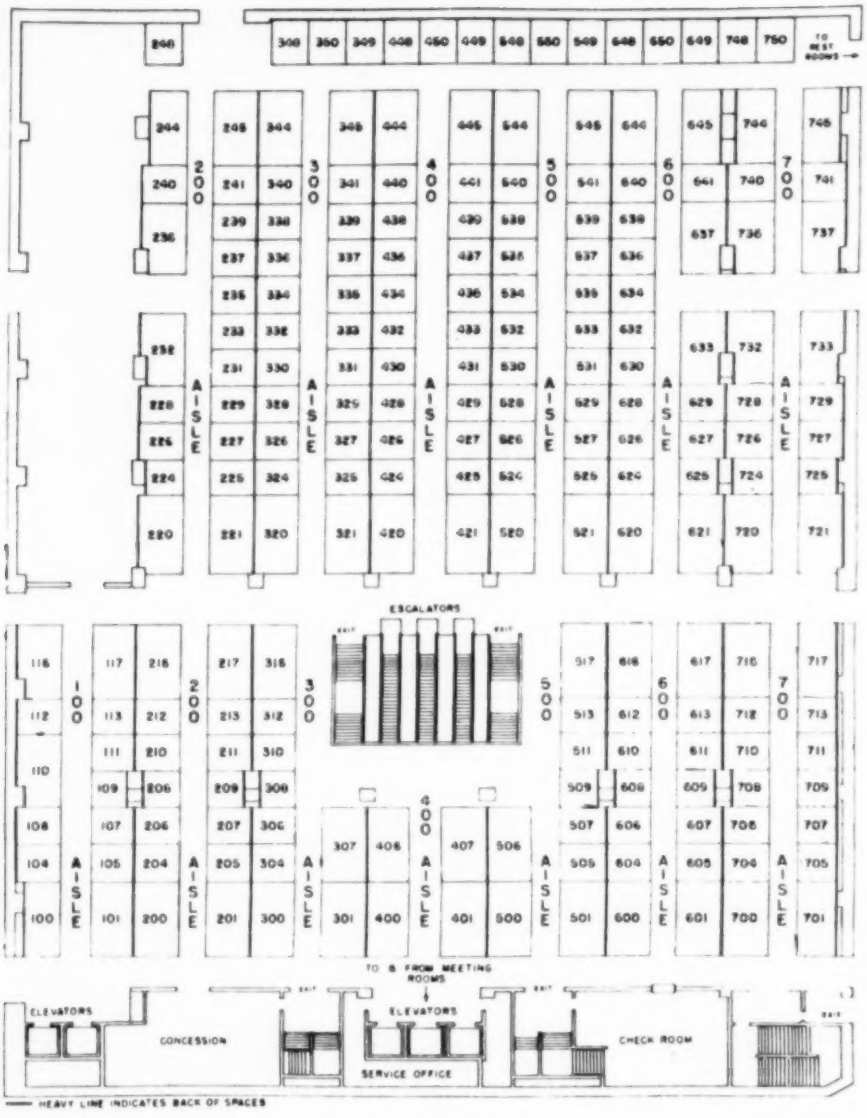
Consultants Bureau, Inc., New York, N. Y.
Cover to cover translation of Soviet Journal on atomic energy. **607**

Controlled Atmosphere Enclosures Mfg. Co., Inc., Jacksonville, Fla.
"Safety" enclosures & dry boxes of stainless steel & plastic, also new sodium arc gas purification system. **334**

Controls for Radiation, Inc., Cambridge, Mass.
Health physics services, low level radiological & other analytical services,

continued on page 124

Floor plan–1960 Atomic Exposition–New York Coliseum



Guide to Atomic Exhibitors (continued)

advanced conceptions in dosimetry & other research areas, & FIDO—miniature radiation alarm. **632**

Cooper Metallurgical Associates, Cleveland, Ohio.
Ductile chromium, high purity boron, high purity borides, aluminum-boron alloys, & copper-boron alloys. **605**

Crossroads Marine Disposal Corp., Boston, Mass.
Radioactive disposal vessels & inexpensive air raid nuclear shelters. **226**

Damascus Tube Co., Greenville, Pa.
Damascope testing equipment, also material & special tubing made by their new FLO-ROL process, various exotic metals. **240**

Daven Co., The, Livingston, N. J. **327**

Elcor, Inc., Falls Church, Va.
Model A309A current indicator & integrator, transistor—regulated isolated power supplies, & low-capacitance isolation transformers. **210**

Eldorado Mining & Refining, Ltd., Port Hope, Ont.
Uranium metal compounds & concentrates. **501-517, 600-616**

Electronic Associates, Ltd., Willowdale, Ont.
Geiger tubes, equipment utilizing radioisotopes, radiation detection equipment. **501-517, 600-616**

Encyclopaedia Britannica, New York, N. Y.
Encyclopaedia Britannica Senior, Britannica Junior, World Atlas & Britannica Seven Language Dictionary (two volumes). **339**

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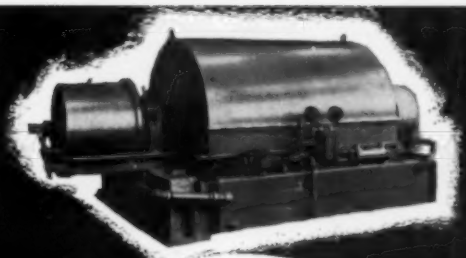
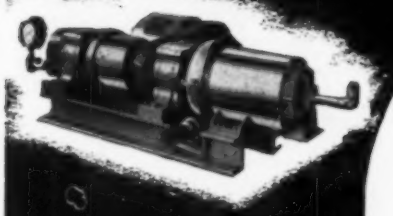


Bird Continuous Solid Bowl Centrifugal, 54 in. bowl dia., delivers up to a ton or more per minute of well dewatered solids.



Bird Solid Bowl Centrifugal, 6 in. bowl dia., operates at up to 6000 rpm.

why so many different Birds?

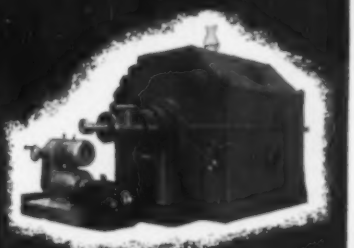
Solid-Liquid Separating Jobs differ

in volume
in solids characteristics
in liquid characteristics
in feed consistency
in feed temperature
in wash requirements
in end result requirements

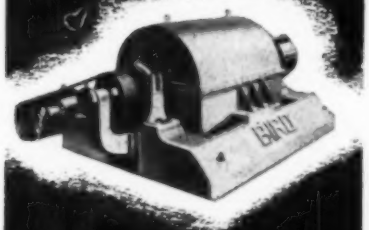
That is why Bird solid-liquid separating equipment covers such a wide range of types, sizes and designs — why it is, in effect, custom engineered to fit the specific job.

The Bird for *your* job will do it better, or faster, or cheaper — or else it won't be recommended. You can depend on that.

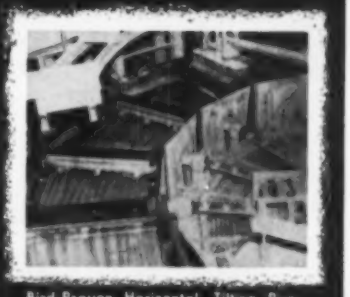
The Bird Research and Development Center is equipped to make pilot-scale tests of *your* feed slurries under *your* operating conditions and come up with findings that you can accept with full understanding and confidence.



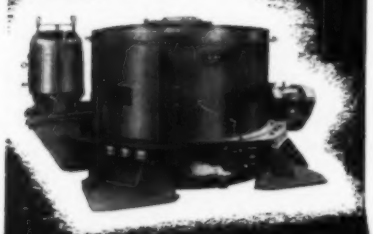
Bird-Young Rotary Vacuum Filter provides several times the usual capacity per foot of filter area. Operates totally enclosed, fume-tight when desired.



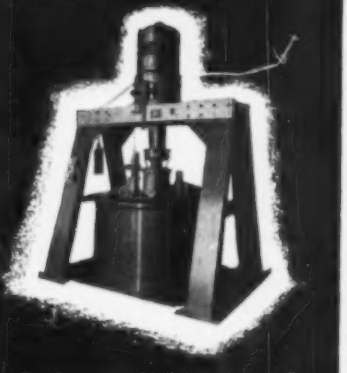
Bird Solid Bowl Centrifugal, 24" bowl dia., one of seven sizes, each subject to 25 design variations.



Bird-Prayon Horizontal, Tilting Pan, Vacuum Filter combines large capacity with super-effective, multi-stage washing.



Bird-Humboldt Oscillating Screen Centrifuge dewaters plus 65 mesh solids with almost no degradation or solids loss.



Bird Suspended Batch Centrifuge, 40" or 48" basket, perforate or imperforate.

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MACHINE COMPANY

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Eaton-Dikeman filter papers help National Foam System fight fire effectively

"Fire fighting foam liquids must be free from all suspended solids to insure chemical stability and satisfactory performance in the equipment in which they are used. We believe our Aer-O-Foam fire fighting foam liquids are the *cleanest* in the world," says D. N. Meldrum, Chemical Director, National Foam System, Inc., West Chester, Pa.

At National Foam, natural protein is hydrolyzed in an alkaline medium and further treated to extract foam stabilizing fractions from the protein. The digested material is filtered through Eaton-Dikeman filter paper grade 953 laid over cloth on a 36" Sperry press to remove undesirable fractions and solid residual material. The use of E-D filter paper with the cloth filter gives National Foam two advantages: (1) a much higher degree of filtration than would be possible with cloth alone, and (2) production costs are cut because the filter cake is built up on the inexpensive filter paper, allowing the more expensive filter cloth to be re-used.

Filtering protein extracts in manufacturing fire fighting foam liquids may not be your particular problem, but whatever you filter, chances are you can do it better, faster and at less expense with one of Eaton-Dikeman's many grades. Why not talk it over with an E-D filtration expert. He will be happy to help you find the right paper for your particular requirement. In the meantime, send for a FREE sample folder of quality E-D papers today.

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Exhibitors

from page 124

Erskine Healy, Inc., Rochester, N. Y.
Neoprene research gloves. **609**

Etablissements Kuhlmann & Subsidiaries, Paris, France. **221-233, 320-332**

Flanders Filters, Inc., Riverhead, N. Y.
AIRPURE absolute type filters & supply purification units for the removal of chemical bacteriological & radiological materials. **532**

Florida Development Commission, Tallahassee, Fla. **244**

Ford Instrument Co., Long Island City, N. Y.
Nuclear ship conversion techniques, gas-cooled reactor developments, reactor instrumentation & controls, & direct conversion developments. **637**

Foster Engineering Div., General Controls Co., Warwick, R.I.
Gentile flow tubes, reducing valves, pressure & temperature regulators and vacuum breakers. **449-450**

French Expositions in the U. S., Inc., New York, N. Y. **221-233, 320-332**

General Atomic, Div. of General Dynamics Corp., San Diego, Calif. **613-617**

General Controls Co., Glendale, Calif.
Electro-hydraulically operated valves. **449-450**

General Electric Co., Schenectady, N.Y.
Amplifiers, control rod drive mechanisms, counting rate meters, fuel element fabrication, fuel elements (nuclear), etc. **541-545**

Griscom-Russell Co., The, Massilon, Ohio.
Liquid metal heated steam generator & associated nuclear equipment. **441**

Groupment Atomique Alsacienne Atlantique, Paris, France. **221-233, 320-332**

Gunnar Mines, Ltd., Toronto, Ont., Canada.
Uranium concentrates. **501-517, 600-616**

Hammel-Dahl Div., General Controls Co., Warwick, R. I.
Diaphragm control valves—bellows sealed, high vacuum valves, & swing check valves. **449-450.**

Hamner Electronics Co., Inc., Princeton, N. J. **338**

Harshaw Chemical Co., The, Cleveland, Ohio.
Large dia. sodium iodide crystals for total body counting, combination sodium iodide - phototube assemblies — "Harshaw Integral Line," lithium iodide for neutron detection, & alkali halide optical crystals. **438**

Harvey Aluminum, Inc., Torrance, Calif.
Zirconium, titanium, & aluminum mill products. **433-435**

High Voltage Engineering Corp., Burlington, Mass. **439**

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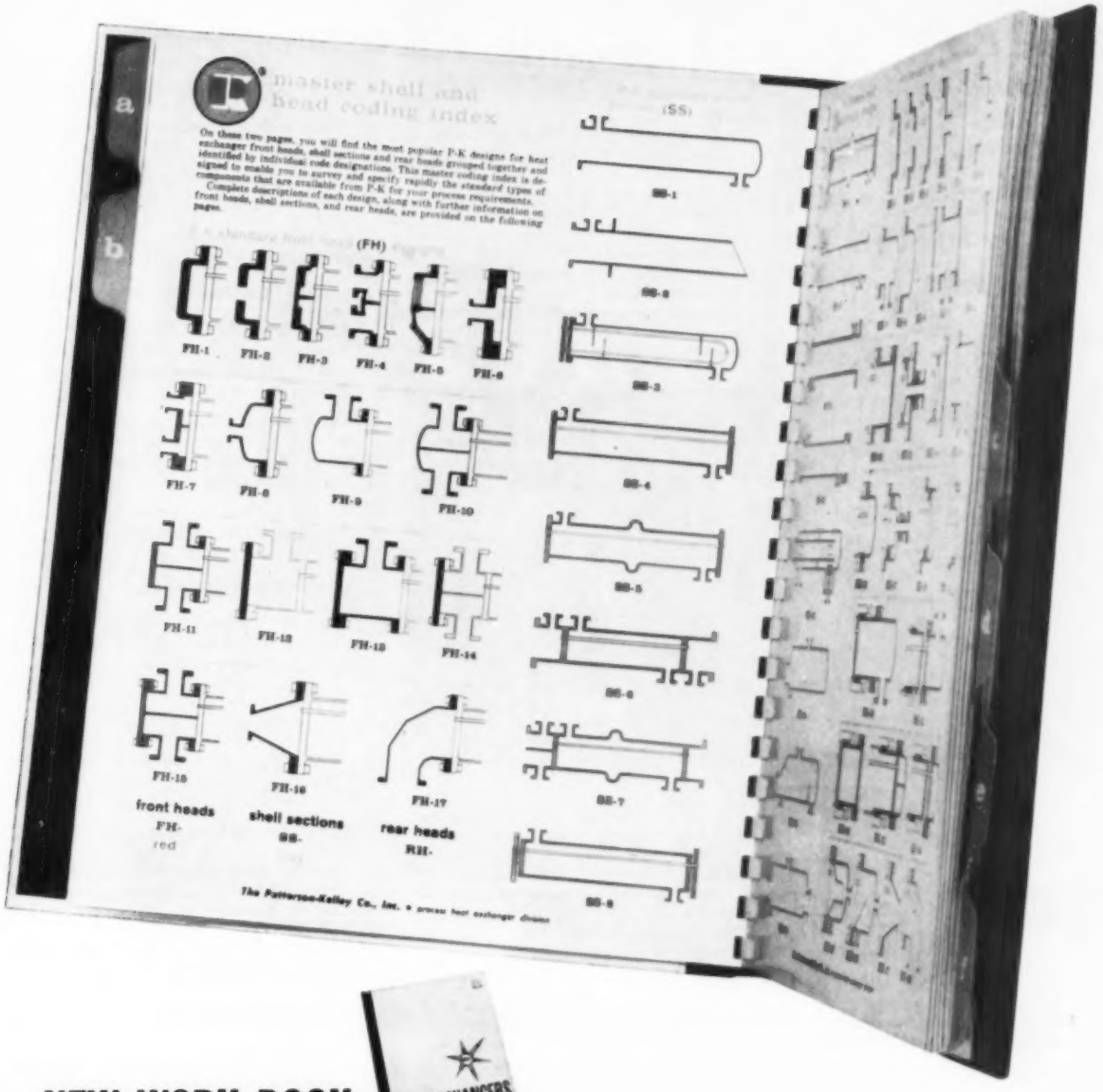


NEW WORK BOOK SIMPLIFIES HEAT EXCHANGER SELECTION

The need for a standard terminology to simplify communications between P-K and engineers in the chemical processing industry has been met in P-K's new Heat Exchanger Manual.

This unique communications tool illustrates and describes components of shell and tube heat exchangers commonly used in processing. A complete system of interchangeable front heads, shells and rear heads is established. Fundamentals of heat transfer and design are reviewed. Even economic considerations are discussed. The simple, certain nomenclature saves time, effort and duplication of engineering work.

This 120-page manual, indexed and bound in hard covers, will be supplemented from time to time with new technical material. Names of holders will be registered to receive such material as it appears.

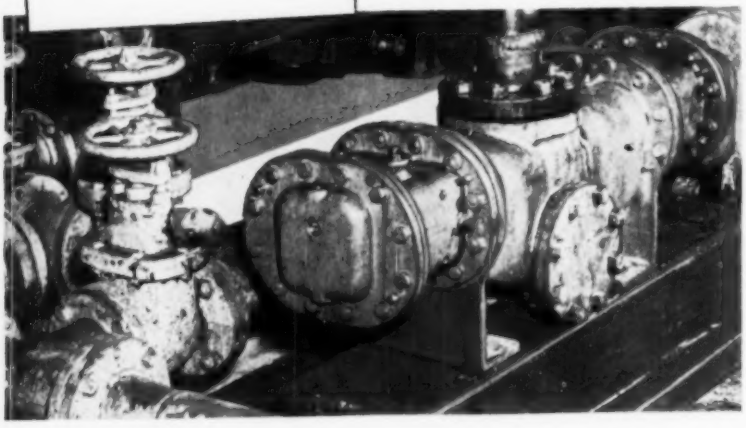
Only a limited number of copies is available and, naturally, these should go to those in the process industries who will benefit most from the information we have compiled. If you design or specify heat exchangers, write us on your company letterhead, outlining briefly areas of your interest. A few copies are available to students and non-technical personnel at a nominal charge. Patterson-Kelley Co. Inc., E. Stroudsburg, Pa.

Patterson Kelley
Heat Exchanger Division

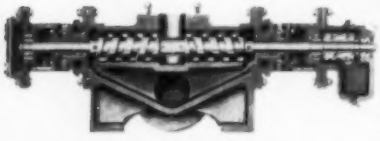
Sier-Bath SCREW PUMPS

— pumping 200 g.p.m. of viscous Tallow and Castor Oil to plant ½ mile away, with 45 foot elevation.

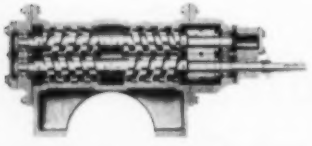
FELS & CO., Philadelphia, Pa., 2 years ago replaced a costlier pump with this lower-cost Sier-Bath Screw Pump and gained high-efficiency pumping with low maintenance and operating costs. Less heat is required for tallow, while castor oil is pumped cold, saving on steam. Uniform flow rate regardless of suction head, permits computing accurately amounts of material drawn from storage at any given time. Pump operates intermittently 8 hours a day and is fully automatic.



Sier-Bath SCREW PUMPS



External Gear and Bearing Bracket Type for non-lubricating liquids and semi-liquids



Internal Gear and Bearing Type for lubricating liquids and semi-liquids

Sier-Bath Screw Pumps maintain high volumetric efficiency because "Dual-Controlled" precision rotor design prevents rotor-to-rotor or rotor-to-casing contact—provides a continuous flow without pulsation, hammering or vibration . . . without strains, misalignment and wear on rotors, shafts, bearings and gears.

Result: Dependable, uninterrupted pumping service—less maintenance—easier servicing—longer pump life—lower overall pumping costs.

Capacities from 1 to 2,000 gpm.; viscosities from 32 SSU to 1,000,000 SSU.; discharge to 1,000 psi. for viscous liquids, 200 psi. for water and light oils. Horizontal or vertical construction. Corrosion resistant alloys, special bodies, stuffing boxes and bearings for special needs. See "Yellow Pages" for your Sier-Bath representative or write Sier-Bath Gear & Pump Co., Inc., 9272 Hudson Blvd., North Bergen, N. J.

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Founded 1905 **Mfrs. of Precision Gears, Rotary Pumps, Flexible Gear Couplings** **Member A.G.M.A.**

For more information, turn to Data Service card, circle No. 21

Exhibitors

from page 126

Hispano Suiza France, Bois Colombes, France. **221-232, 320-332**

Hughes Aircraft Co., Culver City, Calif.
Mark IB Mobot—A remotely controlled handler, miniature solid state radiation detector & associated system & gamma electron linear accelerator. **307**

Instron Engineering Corp., Canton, Mass.
Special remote tensile testing instrument for use in hot cell, also standard line of tensile compression testing instruments. **521-525**

International Nickel Co., Inc., New York, N. Y.
Various applications of nickel alloys in the nuclear field. **217**

Kaman Nuclear, Colorado Springs, Colo.
The PULSATRON, pulsed neutron generator. **448**

Kollmorgen Optical Corp., Northampton, Mass.
Hot cell periscopes, sealing dome assembly, borescopes, precision optics & optical—mechanical—electronic instruments & systems. **624**

Landsverk Electrometer Co., The, Glendale, Calif.
Dosimeters, roentgen meter standards, isotope analysis unit & military radiacmeters. **426**

Lerma Engineering Corp., Northampton, Mass.
Optical equipment specifically for nuclear field featuring Omniscope with 180 deg. true field. **208**

Librascope, Inc., Div. of General Precision, Glendale, Calif.
Libratrol 500 control computer, model 210 X-Y plotter, explosive ordnance components. **644**

Lockheed Nuclear Products, Lockheed Aircraft Corp., Atlanta, Ga.
Engineering & design services, reactors, meteorological research & irradiation services. **601**

Lundell & Co., Mt. Prospect, Ill.
Statalarm solid state annunciator, record-alarm event recorder, set point monitors & reactor monitoring & shutdown devices. **440**

McGraw-Hill Publishing Co., New York, N. Y.
Nucleonics & Buyer's Guide. **312**

M & C Nuclear, Inc., Subsidiary of Texas Instruments, Inc., Attleboro, Mass.
Clad UO_2 fuel rods, uranium-aluminum fuel elements, UO_2—SS cermet fuel assemblies, & experimental materials: U & Th foils, discs, fission plates, etc. **520**

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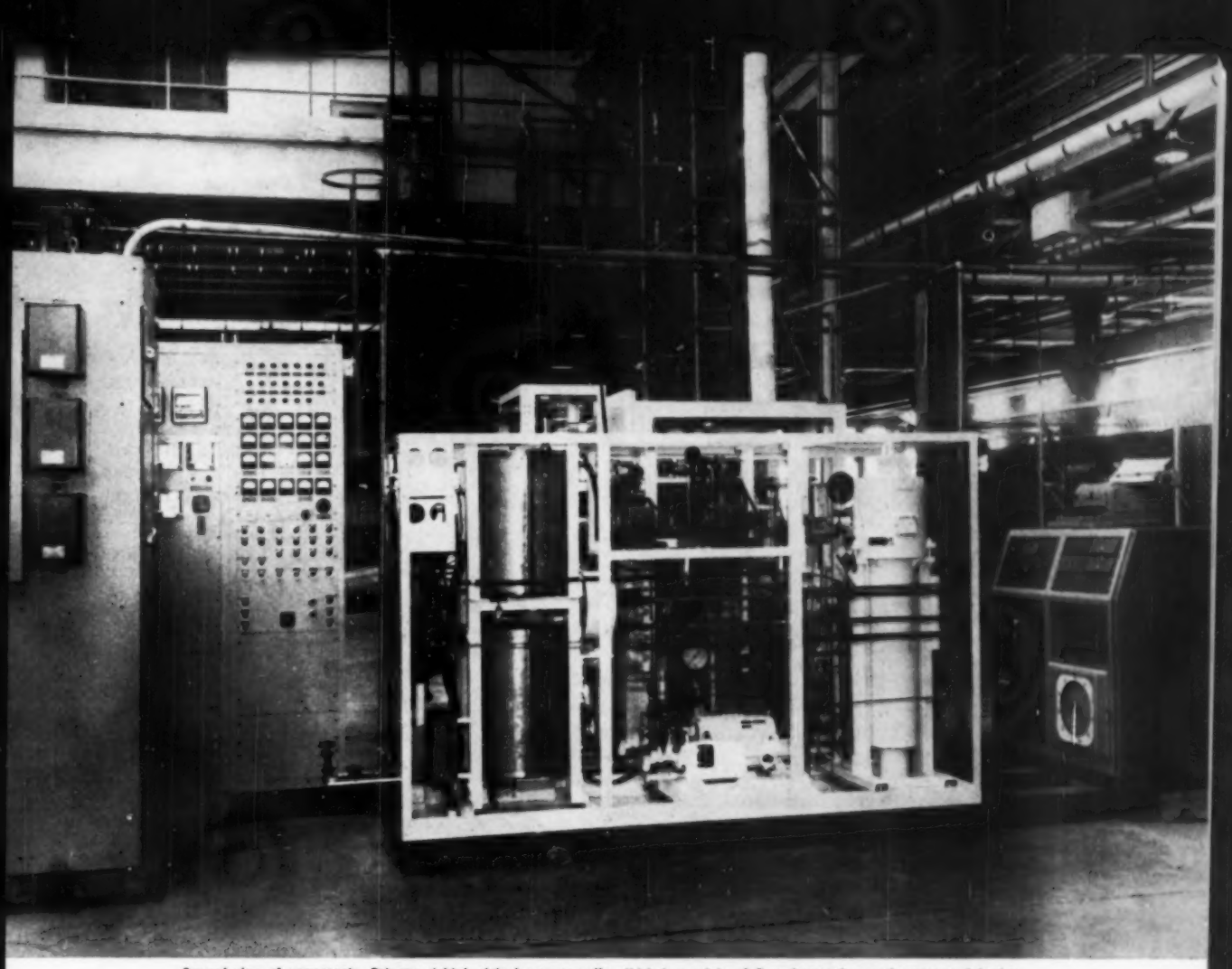

General view of components. Extreme right is data logger recording thirty-two points of flow, temperature and pressure. Asbestos covered line in rear is the in-pile line. The farthest section is that which will be inserted in reactor. Unit in center contains make-up pump, vacuum pumps and neutron detector. All units are in respective positions as they will be placed on the balcony of reactor.

TEST LOOP FOR NUCLEAR REACTOR FABRICATED AT LUMMUS' ENGINEERING DEVELOPMENT CENTER

The Lummus Company Engineering Development Center, Newark, N. J., recently completed the fabrication, assembly, test operation, and dismantling of a ¾" In-pile Test Loop designed and constructed for Westinghouse Electric Corporation, Atomic Power Department, as a part of the AEC Research and Development Contract AT-(30-3)-222. This loop was built for experiments in connection with irradiation of fuel element and control rod designs for the nuclear power reactor to be installed by the Yankee Atomic Electric Company at Rowe, Massachusetts. The reactor is being designed by Westinghouse for Yankee. Upon delivery to the Materials Testing Reactor at Idaho Falls, the loop will be installed and operated to simulate actual reactor conditions on fuel element and control rod samples.

The purpose of this experiment is to study the performance of the fuel element design and its resistance to corrosion under irradiation in plant environment. It is also intended to investigate the suitability of the control rod materials. In addition to this, during the first months of operation, a water chemistry stability study is planned.

Owing to the limited space available at the Materials Testing Reactor, the entire loop was constructed in two cubicles, an instrument panel, and a motor control center. All of the components other than controls were contained in these two cubicles. Careful planning was required to insure that all equipment would fit and that there would be no piping interferences. After assembly, the loop was operated at The Lummus Company Engineering Development Center to insure meeting of engineering specifications and reliability of components. After this operation and acceptance by the customer, the cubicles, motor control centers, and instruments were individually packed and shipped to Idaho Falls for reassembly by Phillips Petroleum Company personnel, who operate the Materials Testing Reactor.

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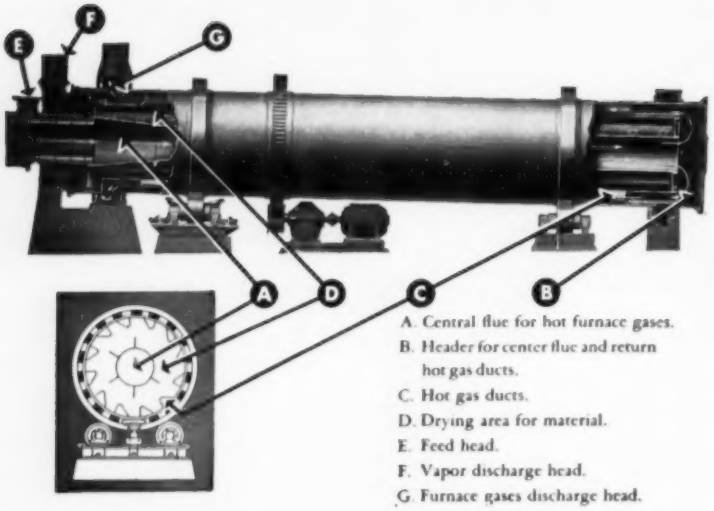

A. Central flue for hot furnace gases.
B. Header for center flue and return hot gas ducts.
C. Hot gas ducts.
D. Drying area for material.
E. Feed head.
F. Vapor discharge head.
G. Furnace gases discharge head.

Ruggles-Coles INDIRECT-FIRED DRYERS and HEATERS

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- Minimize auxiliary dust collection when handling fine precipitates and filter cake.
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- Available fabricated with heat and corrosion-resistant metals.

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For more information, turn to Data Service card, circle No. 161

Exhibitors

from page 128

Mallinckrodt Nuclear Corp., St. Louis, Mo.
Uranium dioxide ceramic grade, uranium dioxide pellets, uranium dioxide shot & uranium metal. **407**

Manufacture Francaise De Vide Touries Automatiques, Paris, France. **221-233, 320-332**

Marquardt Corp., The, Van Nuys, Calif.
High temperature actuators, high temperature sensing devices, high temperature controls components. **626-628**

Martin Co., The, Nuclear Div., Baltimore, Md.
Flat plate, tubular & ceramic rod type fuel elements, PM-1 portable reactor system, liquid fluidized bed reactor, isotopic power units. **300-304**

Marvel-Schebler Products Div., Borg Warner Corp., Decatur, Ill.
Control rod drive mechanisms, nuclear reactor control systems, & other engineered nuclear products. **331-333-335**

Merck & Co., Ltd., Montreal, Que.
Radioisotopes. **501-517, 600-616**

Metronix, Inc., Chesterland, Ohio.
New AC-DC electronic voltmeter in half relay-rack mounting, one panel-mounting electronic voltmeters, & new portable transistor test set. **645**

Minneapolis-Honeywell Reg. Co., Philadelphia, Pa.
Nuclear amplifiers, recorders, & rod controllers, electric control system—transducers, receivers, control stations, & valve actuators, etc. **544**

National Lead Co., New York, N. Y. **538-540**

North American Aviation, Inc., Vernon, Calif. **430-432-434**

North American Van Lines, Inc., Ft. Wayne, Ind.
Specializing in the handling of delicate, electronic & other high-value products. Both within and without the Continental United States. **611**

Nuclear Data, Inc., Wheaton, Ill.
Multi-channel analyzer, scintillation detectors. **633**

Nuclear Develop. Corp. of Amer., White Plains, N. Y. **500**

Nuclear Enterprises, Ltd., Winnipeg, Manitoba.
Scintillometers, scintillation plastics. **501-517, 600-616**

Nuclear Materials & Equipment Corp., Apollo, Pa.
Nuclear fuel materials, powder metallurgy products, cathodic vacuum etcher, & electronic balance. **444**

Nuclear Measurement Corp., Indianapolis, Ind. **634**

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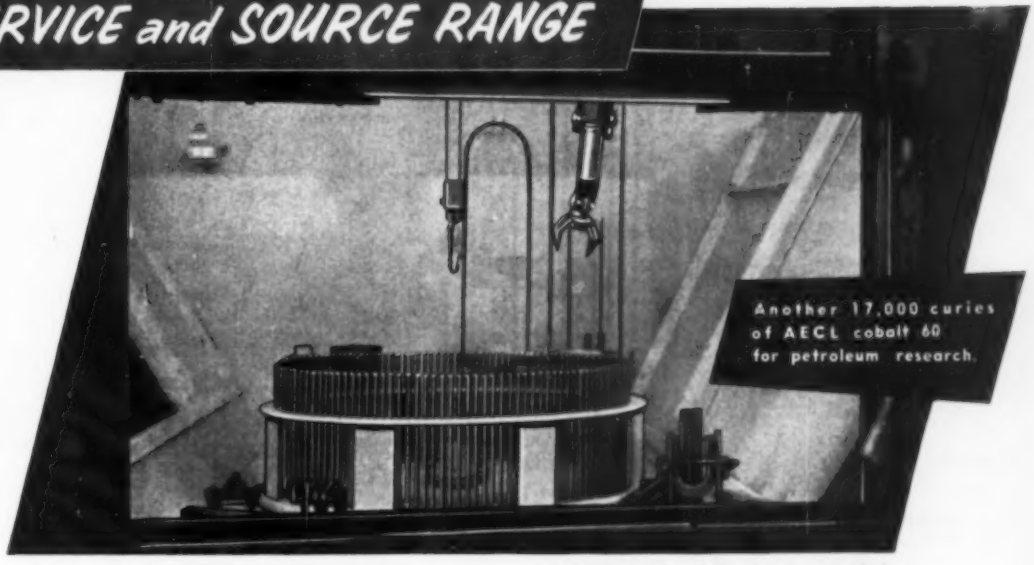
A complete COBALT 60 SERVICE and SOURCE RANGE



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Bulletin No. 31-A

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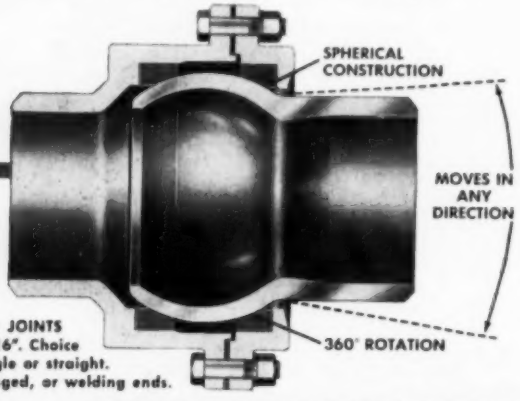
SEE your Barco Representative for information or write. Ask for the new revised Bulletin No. 31-A, "How to Solve Piping Flexibility Problems." *Engineering recommendations on request.*



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The Only Truly Complete Line of Flexible Ball, Swivel, Swing and Revolving Joints
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For more information, turn to Data Service card, circle No. 3

Exhibitors

from page 130

Ontario Research Foundation, Toronto, Ont.
Research & design services.
501-517, 600-616

Orenda Engines, Ltd., Toronto, Ont.
Reactors, reactor design, nuclear components. **501-517, 600-616**

Pacific Coast Engineering Co., Alameda, Calif.
Reactors, pressure vessels, cranes, & leaded containers & shielding. **211**

Pechiney, Paris, France.
221-232, 320-332

Pergamon Press, Inc., New York, N. Y.
International & scientific books & journals. **224**

Permali, Inc., Mount Pleasant, Pa.
New neutron shielding material, Permali "N" **539**

RCA Service Co., Div. of Radio Corporation of America, Camden, N. J.
Radiation surveys, instrumentation maintenance programs, equipment & system installation services, & ultra high vacuum systems. **630**

Radiation Counter Laboratories, Inc., Skokie, Ill. **310**

Radiation Instrument Development Laboratory, Inc., Chicago, Ill.
Model 34-8 transistorized 200 channel pulse height analyzer, Model 34-9 400 channel pulse height analyzer, Model 49-4 SCAMP system, & Model 50-1 single channel automatic spectrometer. **201**

Research Equipment Co., Glen Ellyn, Ill.
Radiation shielding windows, periscopes, remote positioning devices, & filter changing equipment. **213**

Reuter-Stokes Electronic Components, Inc., Cleveland, Ohio.
Neutron detection devices including BF_3 proportional counters, boron lined ionization chambers, fast neutron detectors, gamma ionization chambers, etc. **209**

Riggs Nucleonics Corp., Burbank, Calif.
Gamma single & multichannel area monitoring systems, ionization chambers & portable survey meters. **340**

Saint-Gobain, Compagnie de, Neuilly, France. **221-233, 320-332**

Sarnia Inspection Co., Sarnia, Ont.
Inspection services using radioactive sources. **501-517, 600-616**

Societe Alsacienne De Constructions Mechaniques, Paris, France.
221-233, 320-332

Societe Electrometallurgique Du Planet, Paris, France. **221-233, 320-332**

Societe Industrielle De Combustible Nucleaire, Paris, France.
221-233, 320-332

Societe Industrielle d'Etudes et de

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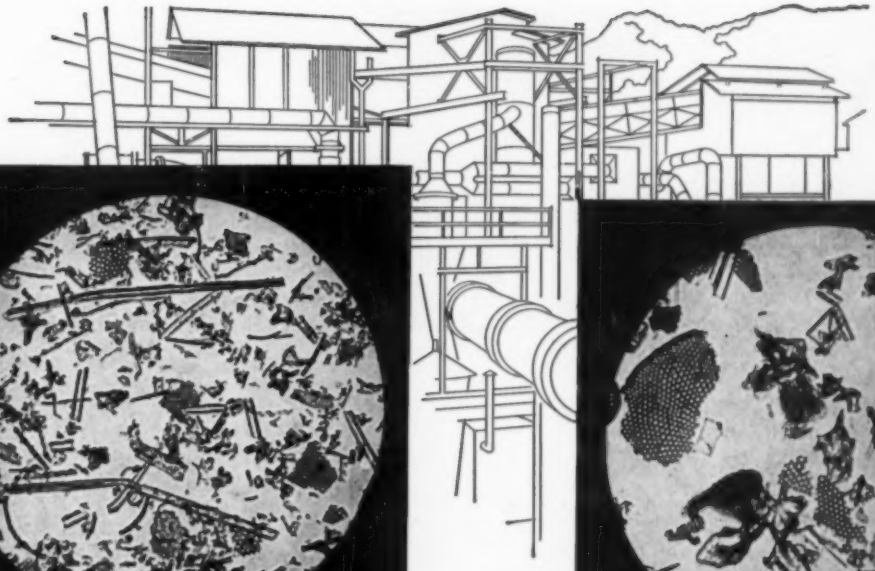
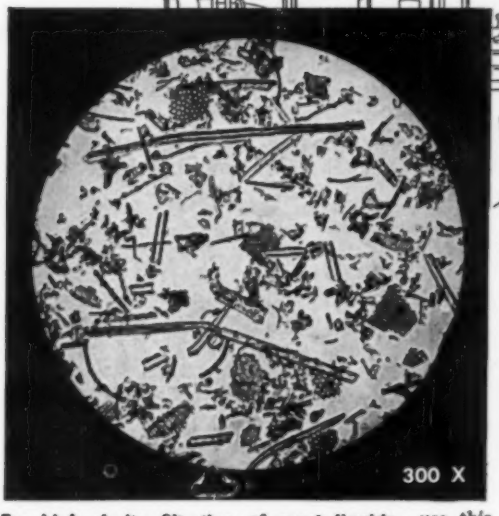
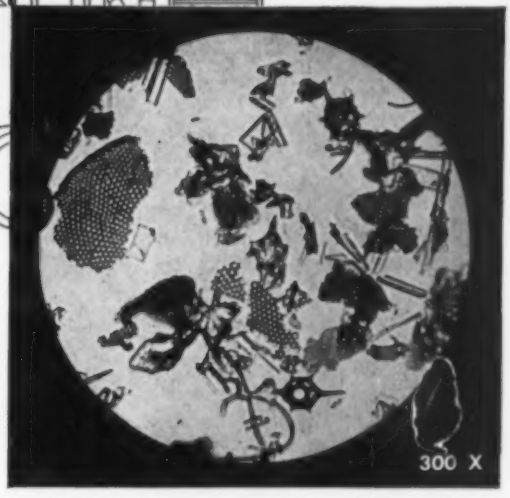


Milling and calcining equipment used for all Celite grades.



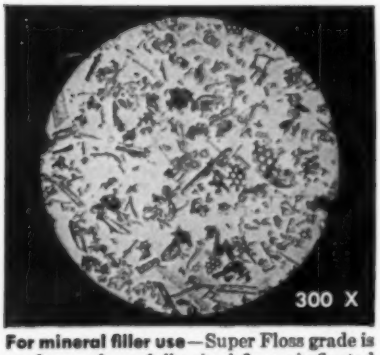
For high-clarity filtration of most liquids—use this specially milled diatomite, Hyflo Super Cel.



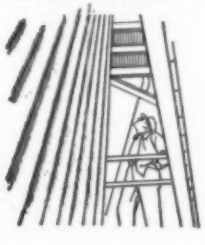
For filtration of larger suspended particles—Celite 545 combines maximum clarity plus faster flow rates.

In diatomites, Johns-Manville precision processing works for you

Constant uniformity in every grade of Celite assures consistent results, less down-time



For mineral filler use—Super Floss grade is made up of carefully sized fines air-floated off in the bag house.



Typical J-M bag house equipment.

As the microscope shows, each grade of Celite* diatomite has its own distinctive particle size distribution. Yet no matter where or when purchased, each remains uniform from bag to bag—your assurance of top production results with minimum down-time.

Three examples of flux-calcined Celites are shown here. Hyflo® Super Cel is widely used for filtration in many industries. It has just the right combination of coarse and fine particles to assure optimum clarity and flow rates. Celite 545, with a higher percentage of coarse particles, is used to achieve maximum clarity and faster flow rates with liquids that have larger suspended particles.

Super Floss, one of several bag house grades, has fine particle size distribution. A white powder, it is processed within very narrow tolerances (less than 1% retained on 325 mesh). It is a popular filler in fine products such as silver polishes.

Johns-Manville can precision-produce so many different grades of Celite because it mines the material from the world's largest and purest commercially available deposit. For assistance with specific filtration or mineral filler problems, talk to a nearby Celite engineer. Or write direct to Johns-Manville, Box 14, New York 16, N. Y. In Canada, Port Credit, Ontario.

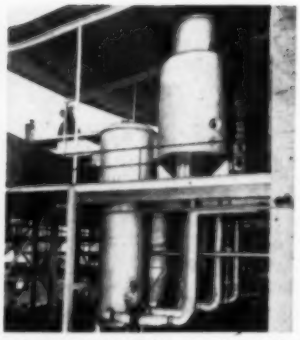
*Celite is Johns-Manville's registered trade mark for its diatomaceous silica products.

JOHNS-MANVILLE

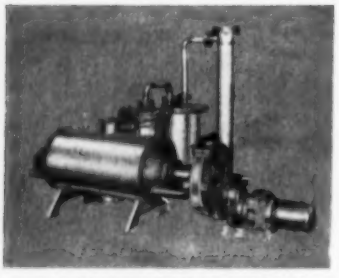
For more information, turn to Data Service card, circle No. 92

G-B

PROCESS EQUIPMENT

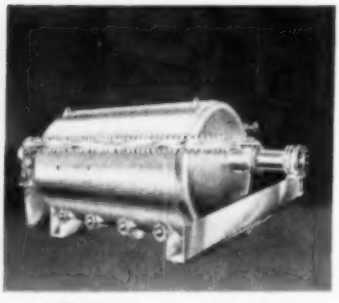


▲ EVAPORATOR — All stainless steel quadruple effect.



▲ VACUUM ROTARY DRYER — Designed for efficient removal of moisture at low temperatures.

▲ DRUM DRYERS — Available with a variety of feed arrangements.



▲ FILTER — All stainless steel. Vallez rotating leaf pressure filter. Designed for precoat if required.

Goslin-Birmingham process equipment is custom designed to meet your specific requirements. The high standards of G-B design and workmanship assure you of maximum operating efficiency.

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For more information, turn to Data Service card, circle No. 138

Exhibitors

from page 132

Realisations Scientifiques, Paris, France.
221-233, 320-332

Societe Jahan, Paris, France.
221-233, 320-332

Sorel Industries, Ltd., Montreal, Que.
Reactor component fabrication.
501-517, 600-616

Technical Associates, Burbank, Calif.
Low level beta counting system including shield & anti-coincidence instrumentation, automatic sample changer for 200 samples, alpha hand monitor (scintillation type), & 5000 volt regulated high voltage supply.
301

Technical Measurement Corp., North Haven, Conn.
Instrumentation for the measurement & analysis of radioactivity, scalers & analyzers. **236**

Teleflex, Inc., North Wales, Pa.
Control rod drives, instrumentation, special mechanisms, & remote controls.
445

Thompson Ramo Wooldridge Inc., Cleveland, Ohio.
RW-300 process control computer, reactor control rod drive mechanism, reactor core structural components, closed circuit television, electro mechanical systems, & engineering for the nuclear industry. **550-549-648**

Timken Roller Bearing Co., The, Canton, Ohio.
Exhibiting products made principally from 304, 348 and 410 grades of Timken stainless seamless steel tubing.
226

Traceriab, Inc., Richmond, Calif.
5 Channel area radiation monitor, MAP-1 continuous air particulate monitor, MWP-4 continuous low level liquid monitor, MWP-1A fission products water monitoring system. **620**

Union Carbide Corp., Long Island City, N. Y. **421-431**

United Nations, New York, N. Y.
Complete Proceedings of the Second United Nations International Conference on the Peaceful Uses of Atomic Energy held in Geneva, Switzerland in September of 1958—English edition—33 volumes. **627**

U. S. Nuclear Corp., Burbank, Calif.
Health physics services, environmental testing, beta, gamma & neutron sources, also shields & handlers.
629

U. S. Steel Corp., Pittsburgh, Pa.
USS quality forgings, USS National pipe & tubes, alloy & stainless steels; & products & services of Consolidated Western Steel Division. **400-406**

continued on page 136

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Exhibitors

from page 134

Van Nostrand, D., Co., Inc., Princeton, N. J.
Reference books on nuclear science & related titles. **235**

Vard, Inc., Div. of Royal Industries, Inc., Pasadena, Calif.
Nuclear core control rod drive mechanisms, electro-mechanical actuators, (rotary & linear) precision gear boxes. **220**

Velan Engineering, Ltd., Montreal, Que.
Valves for reactors. **501-517, 600-616**

Victoreen Instrument Co., The, Cleveland, Ohio.
Spectrometers, monitoring systems, medical radiation measuring instruments, personal dosimeters & chargers, survey meters, preamplifiers, etc **321**

Vitro Corporation of America, New York, N. Y. **316**

Wah Chang Corp., New York, N. Y.
Columbium, zirconium, hafnium, tungsten. **200**

Westinghouse Electric Corp., Pittsburgh, Pa. **420-424**

Technical sessions

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2:00 p.m.

REACTOR—SESSION I—U. S. POWER REACTORS
Chairman: Sidney Baron, Burns and Roe, Inc.

The Army Nuclear Power Program, Donald G. Williams, Colonel, CE, Chief Army Nuclear Power Program

Budocks Role in the Development of Nuclear Power for The Navy's Shore Bases, W. J. Christensen, Commander, CEC, USN, Manager, Atomic Energy and Applied Science Branch, BUDOCKS, Dept. of The Navy

Reactor Development in The Next Ten Years, Frank Pittman, AEC Reactor Dev., U. S. AEC

Sites for Nuclear Power Plants for Large Spanish Utility, Jamie Mac-Veigh, President, Tecnatom

TUESDAY, APRIL 5

9:30 a.m.

ENVIRONMENT—SESSION II—STATE-FEDERAL REGULATIONS PROTECTING PUBLIC HEALTH
Chairman: Merrill Eisenbud, New York University

Status of Regulation at the Municipal Level, Hanson Blatz, New York City Health Department

Status of Regulation on the State Level, Oliver Townsend, New York State Office of Atomic Development

Status of Regulation on Federal Level: Responsibilities of The U. S. Public Health, Francis J. Weber, Chief, Div. of Radiological Health, Dept. of Health, Education and Welfare.

Status of Regulation on International Level, A. I. Galagan, International Atomic Energy Administration, United Nations

9:30 a.m.

MATERIALS AND COMPONENTS—SESSION II—FUEL TECHNOLOGY
Chairman: Lauchlin M. Currie, The Babcock and Wilcox Co.

Ignition and Detonation of Uranium in Bromine Triflouride Solutions, R. Johnson, F. Horn, G. Strickland, Brookhaven National Labs.

Uranium-Thorium Reprocessing; Cost Outlook for Commercial Operation, R. J. Klotzbach

Low Impurity Core Materials, G. Pancer, J. L. Zegger, Alco Products

Status of The Plutonium Re-Cycle at Hanford, Roy E. Dunn, Hanford Atomics Products Op., General Electric Co.

9:30 a.m.

REACTOR—SESSION II—RESEARCH REACTORS AND RADIATION FACILITIES
Chairman: Hugh Neale, AMF Corp.

Operation and Experimental Use of The Battelle Research Reactor, A. M. Plummer, J. N. Anno, J. W. Chastain, Jr., Battelle Memorial Institute

Operating Experience With In-Pipe Loops at ORNL, J. A. Cox, ORNL

Construction and Operation of The McMaster Nuclear Reactor, W. H. Pleming, McMaster University

The Design of A Hot Laboratory for Metallurgical Research in Germany, W. Stephan, GFKF Institute Pur Reaktorwerkstoffe

2:00 p.m.

REACTOR—SESSION III—PROGRESS IN REACTOR INSTRUMENTATION
Chairman: H. A. Lamonds, North Carolina State College. Vice Chairman: E. E. Lynch, General Electric Co.

Application of Instrumentation Control, Walter Lapinski, Argonne National Lab.

Basic Requirements of Instrumentation and Control for Closed-Cycle Water Nuclear Power Plants, C. F. Obermesser, Westinghouse Electric Corp.

Control and Instrumentation Equipment—In Core, H. M. Ogle, J. Forster, H. H. Hendon, J. H. Keeler, Atomic Power Equipment Dept., General Electric Co.

Control and Instrumentation Equipment—External, E. P. Epler, ORNAL

Status of Present State of Technology Instrumentation and Control Systems for Nuclear Power Reactors, Frank C. Leger, Harold E. Vann, U. S. Atomic Energy Commission, Division of Reactor Development

2:00 p.m.

ENVIRONMENT—SESSION III—WATER SUPPLY AND WASTE DISPOSAL
Chairman: E. Shaw Cole, Pitometer Associates. Vice Chairman: Ralph E. Fuhrman, Water Pollution Control Federation

A Two-Year Study of Environmental Radioactivity Levels Prior to Nuclear Power Plant Operation, John V. Nehemias, Director of Radiological Health Surveys of National Sanitation Foundation, University of Michigan

Strontium 90 in Surface Water, C. P. Straub, L. R. Setter, P. P. Hallbach, A. S. Goldin, Dept. of Health, Education and Welfare, Robert A. Taft Sanitary Engineering Center

Low-Level Tritium Measurement With The Liquid Scintillation Spectrometer, Warren J. Kaufman, Richard M. Hours, University of California

Radioisotopes In A Municipal Water System Near The Hanford Atomic Products Operation, Robert L. Junkins, General Electric

NUCLEAR STANDARDS SESSION
Chairman: F. L. LaQue, Development and Research, International Nickel Co. Vice Chairman: K. A. Kesselring, DIG Project, Knolls Atomic Power Laboratory

Senior representatives of each of 4 specification and code-writing organizations interested in nuclear standards will present discussion of the interests, aims and methods of

continued on page 139

For more information, circle No. 146

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U.S.I. CHEMICAL NEWS

March ★ A Series for Chemists and Executives of the Solvents and Chemical Consuming Industries ★ 1960

Consumption of Heavy Chemicals Grows with U.S. Living Standard

According to statistics assembled recently by the MCA, every man, woman and child in this country in 1958 used over 46 pounds of caustic soda, 182 pounds of sulfuric acid, 41 pounds of chlorine and 44 pounds of ammonia. Per capita consumption of these basic heavy chemicals has been growing steadily since 1939, when the comparable figures were 16, 73.7, 7.9 and 7.3 pounds respectively.

MCA says that this growing consumption is a broad indication of the increasingly important part chemicals are playing in the nation's material well-being. Of course, these chemicals are not seen by the public in the form in which they are produced. But they are used in the manufacture of thousands of everyday items such as soaps and detergents, wearing apparel, paper, gasoline, and plastic articles.

Polyethylene Production In 1959 Estimated at Over a Billion Pounds

In 1959, for the first time in the history of the plastics industry, the one billion pound production mark was passed, and by two materials—polyethylene and vinyl. The Society of the Plastics Industry estimates that production of polyethylene was 1.2 billion pounds, of vinyl 1.1 billion pounds. Estimated production of either of these two raw materials in 1959 exceeded the total production of all basic plastic raw materials as recently as 1946, when only 994,277,000 pounds of plastic raw materials were produced.

As a manufacturer of polyethylene, U.S.I. has been predicting for some time that this material would be the country's first billion-pound plastic. By the end of 1959, the company's own polyethylene production capacity had reached 175 million pounds, with 125 million pounds of additional capacity scheduled to come onstream in 1960. When expansions are complete, U.S.I. will have an overall production capacity of 300 million pounds annually, and will be the second largest among all polyethylene producers.

New Acetone Data Sheet Just Released By U.S.I.

Specifications, properties, shipping information and uses for acetone are listed in a new data sheet now available from U.S.I. The material is employed widely as a solvent—for cellulose acetate, vinyl resins, fats and waxes, acetylene gas and a host of other industrial products. Acetone is also used in the manufacture of drugs, dyes and plastics, in many other organic syntheses, and as a dewaxing agent for lubricating oils.

The new data sheet can be obtained from U.S.I. sales offices or from the New York office at 99 Park Avenue.

Unique U.S.I. Pilot Plant Supplies Vinegar Makers with Technical Data and Assistance

Ethyl Alcohol Supplier U.S.I. Has Been Operating Vinegar Test Generators Since 1932; Helps Customers with Problems, Studies Production Variables, Keeps Industry Informed.

One of the large uses for industrial ethyl alcohol is in the production of vinegar—an operation which consumes ten million gallons of ethyl alcohol annually. For years, U.S.I. has provided a complete technical service for this industry at a unique pilot plant devoted entirely to the study of vinegar manufacture from ethyl alcohol.

U.S.I. does not make vinegar now, but did make it as dilute acetic acid for chemical raw materials prior to World War II. Consequently, the company has a first hand knowledge of just what kind of help its customers need to turn out the best products most efficiently and economically. U.S.I. supplies this help in three forms: basic studies of the variables in vinegar manufacture; work on customer problems; and regularly published technical news letters to the industry.

Research on Vinegar Production

Over the years a group of specialists, with a highly trained staff, has operated U.S.I.'s battery of vinegar test generators in pursuit of knowledge on such considerations as: vinegar aroma and the constituents of the raw material which contribute to it; calculations of the conversion efficiency of generators; oxygen requirements; packings; heat production and control; nutrients; acid concentrations;

MORE

DL-*Methionine Used to Treat Chronic Peptic Ulcer*

In a 4½-year study reported recently, 54 patients with chronic peptic ulcer were treated orally with the essential sulfur amino acid, DL-methionine (3–6 grams/day) and good clinical results were obtained in 80% of the cases.

The patients treated were divided into two groups: those who received methionine preoperatively only, to see if their ulcers could be healed prior to surgery; and those who were given medical treatment with methionine to prevent or diminish the number of recurrences. Seventeen of 18 cases in the surgical group healed prior to surgery. Twenty-six of 36 cases in the medical group responded favorably. Of these, 23 with duodenal ulcers had long-term good results.

The clinical findings suggest that chronic ulcer patients undergo a kind of stress so as to lose sulfur-containing substances such as mucin. This metabolic loss can decrease resistance of the duodenal mucosa to autodigestion and lead to ulceration.

Dr. J. H. Mueller, of U.S.I.'s Cincinnati Research Laboratory, is shown putting an ethyl alcohol (SDA-35A) charge into a vinegar generator.

Dr. Mueller draws off vinegar sample from test generator in U.S.I.'s vinegar pilot plant at the Cincinnati Research Laboratory.

March ★ **U.S.I. CHEMICAL NEWS** ★ 1960

CONTINUED

Vinegar Pilot Plant

mineral content of waters effects of equipment; effect of alcohol denaturants; bacteriology of the process.

Vinegar News Letters

Since 1953, this research work has been reported to the vinegar industry through a series of news letters which have been issued on the average of four times a year. These news letters are comprehensive reports on matters of vital interest to the field. Not only do they concern themselves with data developed at the U.S.I. pilot plant, but they also present reviews of published data, patents and foreign developments. In 1958, one of these news letters gave a comprehensive report on happenings at the International Vinegar Conference.

Customer Service on Vinegar

U.S.I. customers come to this fully equipped, fully staffed vinegar pilot plant with their production problems. When a manufacturer's yield has dropped off, and he wants to determine the causes and correction, a U.S.I. technician from the research lab will call, when requested, and make a full examination of the problem. After studying similar conditions in the pilot generators U.S.I. can then recommend certain solutions to the problem.

This unique pilot operation was originally headquarters at Baltimore, Maryland, but was moved about a year ago to join other U.S.I. test facilities at the Central Research Laboratories at Cincinnati, Ohio. More complete information on its activities may be obtained from U.S.I., 99 Park Avenue, New York 16, N. Y., on request.

Recent Study Determines Rate at Which Undesirable Biuret Forms from Urea

The rate of biuret formation from urea under various conditions was determined in a recent study undertaken to help fertilizer formulators control the presence of this harmful chemical. Biuret, one of the main by-products obtained on heating urea, has a detrimental action on plants and leaves. It is therefore desirable to be able to estimate the rate of its formation from urea under manufacturing and shipping conditions.

The study, made by U. S. I.'s Roderick Shen and published in Agricultural & Food Chemistry, permitted determination of the constants of biuret formation from urea at different temperatures. By use of such constants, the rate of biuret formation from urea solutions at different concentrations can be calculated for any temperature. Results have been put in the form of tables and graphs. Further information may be obtained from U. S. I.

Sodium Reduction Route to Thorium Reported to Give Very High Purity Product

The U. S. Bureau of Mines has developed a new route to thorium which yields the metal at 99.8% purity, with an oxygen content of 200-500 ppm. The process utilizes sodium reduction of the chloride, which was one of the first techniques tried over a century ago when thorium was discovered. At that time, however, it was discarded because it produced a powder with over 3% oxygen content.

New technology on the effective application of alkali metals as reducing agents has brought the process back into use. The modern sodium reduction process not only yields a purer product than the 100-year-old version, but also gives a sponge rather than a powder. This cuts down on handling problems and fire hazard.

By the new method, thorium nitrate is converted to the oxalate with oxalic acid. The oxalate is then reacted with carbon tetrachloride to yield thorium tetrachloride, which is purified by distillation in nickel equipment.

Reaction of the chloride with metallic sodium is carried out in a titanium crucible under an inert atmosphere, by heating to 350-400°C. at the start and then raising the temperature to 850°C. When reaction is completed, the crucible is evacuated. Excess sodium and sodium chloride are distilled off at 900°C. under high vacuum, and the high-purity thorium sponge is recovered for vacuum arc melting to ingots.

TECHNICAL DEVELOPMENTS

Information about manufacturers of these items may be obtained by writing U.S.I.

3,000 Assayed biochemicals for research are described in new reference guide. Sections cover amino acids, peptides, alkaloids, reagents, carbohydrates, enzymes, hormones, purines, pyrimidines, proteins, vitamins, other products. **No. 1570**

n-Butyl myristate (BUMYR) is subject of recent technical bulletin. Material is said to resemble low-viscosity natural oils but without their objectionable characteristics. Suggested for drugs, cosmetics, toiletries. **No. 1571**

Carbon-14 labeled compounds listed in new, 46-page catalog. Includes licensing information, purity methods, other pertinent data. Offers many license-exempt packages. Has special list of hydrocarbons. **No. 1572**

New atmospheric-particle counter now on market said to be designed for continuous monitoring of outdoor or indoor atmosphere. Includes strip-chart recorder, alarm system. Counting rate is 1,000 particles per minute. **No. 1573**

Molybdenum metal is discussed in new, illustrated brochure which includes general description, processing, properties, table of molybdenum products and their uses, wire conversion chart and resistance-temperature chart **No. 1574**

Thioacetamide as analytical reagent is subject of new technical booklet. Material used to precipitate metal sulfides by "precipitation from homogeneous solution." Avoids handling of hydrogen sulfide. Reaction mechanism discussed. **No. 1575**

Sodium-potassium alloys (NaK) and potassium covered in 8-page brochure now available. Details, chemistry, properties, and uses of NaK as heat exchanger fluid in atomic reactors or high temperature processes. **No. 1576**

Cationic chemicals as conditioners for hygroscopic salts and fertilizers are described in new booklet. Formulations, methods of application, recommended uses are included. Field test results with fertilizers also given. **No. 1577**

Detackifier for rubber, said to be widely used in Europe, now being made here in commercial quantities. Used as dip or spray solution. Coats uncured rubber stocks within stable film which prevents adhesion. **No. 1578**

Polyethylene bottle-cardboard carton pack now being used for reagent chemicals. Bottle cap is replaced by pour-spout cap plus tubing and clamp. Carton is inverted and package becomes dispenser. When empty, pack is disposable. **No. 1579**

PRODUCTS OF U.S.I.

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Pharmaceutical Products: DL-Methionine, N-Acetyl-DL-Methionine, Urethan USP, Intermediates.

Heavy Chemicals: Anhydrous Ammonia, Ammonium Nitrate, Nitric Acid, Nitrogen Fertilizer Solutions, Phosphatic Fertilizer Solution, Sulfuric Acid, Caustic Soda, Chlorine, Metallic Sodium, Sodium Peroxide.

PETROTHENE® ... Polyethylene Resins

Animal Feed Products: DL-Methionine, MOREA® Premix (to authorized mixer-distributors).

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Technical sessions

from page 136

their organization in furthering the development of satisfactory standards for the nuclear industry.

ASIM, Normal L. Mochel, Westinghouse Electric Corp.

American Nuclear Society Standards Committee, C. Rogers McCullough, U. S. Atomic Energy Commission

ASME Committee on Nuclear Power of the Boiler and Pressure Vessel, D. A. Robers, Allied Chemical and Dye Corp.

Standardization of the Procedure to Qualify Materials for Nuclear Piping Systems, J. A. Klapper, Ebasco Services Inc.

WEDNESDAY, APRIL 6

9:30 a.m.

REACTOR—SESSION IV—ADVANCED REACTORS AND FUEL CYCLES
Chairman: Lee J. Everett, Philadelphia Electric Co.

Advanced Water Cooled Reactors, W. E. Shoupp, J. H. Wright, Atomic Power Dept., Westinghouse Electric Corp.

Army Gas Cooled Reactors, M. A. Rosen, G. A. Bicher, Capt., Div. of Reactor Development, U. S. AEC

High Temperature, Gas Cooled, Graphite-Moderated Reactor (HTGR), David Rose, John J. Hopkins Lab., General Dynamics Corp.

Nuclear Superheater Designs and Fuel Cycles, E. L. Zebroski, K. M. Horst, P. G. Aline, Atomic Power Equipment Dept., General Electric Co.

9:30 a.m.

ISOTOPE APPLICATION
Chairman: Frank T. Barr, Esso Research and Engineering Company

Industrial Radioisotope Applications Development Sponsored by U. S. AEC, Paul G. Aebersold, Office of Isotopes Development, USAEC

Applications of Nuclear Science in the Producing Branch of the Petroleum Industry, Milton Williams, Humble Oil and Refining Co.

Field Techniques and Instrumentation for Radioactive Gas Tracers, F. E. Armstrong, U. S. Bureau of Mines

Isotopic Power, Jerome G. Mores, Isotopic Power Dept., The Martin Co.

2:00 p.m.

RADIATION PROCESSING SESSION
Chairman: Don Brunton, Curtiss-Wright Corp., Princeton Division. Vice Chairman: M. M. Markels

Progress and Problems in Radiation Processing of Foods, Walter Urbain, Swift and Co.

Commercialization Technology and Economics in Radiation Processing, Herman F. Kraybill, D. C. Brunton, Curtiss-Wright Corp., Princeton Division

Radiation Technology for Non-Biological Materials, A. J. Restaino, Atlas Powder Co., Industrial Reactor Lab.

Current Aspects of The Wholesomeness of Irradiated Foods, Merril Read, Chief, Irradiation Food Branch, Fitzsimmons General Army Hospital

2:00 p.m.

REACTOR DESIGN ENGINEERING SESSION
Chairman: Joe Gallagher, Alco Products, Inc.

Determination of Pressure in a Two Phase Water System, W. H. Comtois, Combustion

Hydraulic Instability of Reactor Parallel Plate Fuel Assemblies, E. B. Johansson, KAPL

Natural Convection Flow in Liquid Metal Mobile Fuel Nuclear Reactors, F. G. Hammitt, E. M. Brower, University of Michigan

A Method for The Economic Comparison of The Th-U-235 Fuel Cycle Versus The U-238-U-235 Fuel Cycle With Application to the MCCR, R. T. Sahnstrom, General Atomic #

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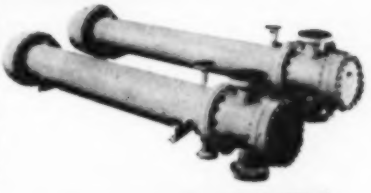

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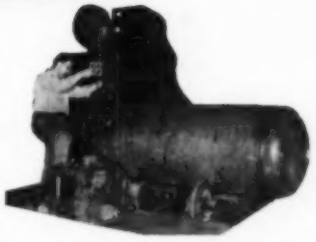

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chemical feature

High polymers in Red China

A review from Chinese sources of recent theoretical and practical accomplishments in the fields of high polymers and synthetic rubbers.

INITIAL STUDIES ON THE olefinic polymerization reactions of synthetic rubber were started in 1950 at the Ch'ang-ch'un Comprehensive Research Institute. In 1953, the Research Institute of Organic Chemistry of the Academia Sinica intensified its research activities in organic glasses and nylon, and in olefinic polymerization and condensation reactions. About the same time, the Research Institute of Chemical Engineering, Ministry of Chemical Industry, also started work on the synthesis of polyvinyl chloride and other high polymers.

Native raw materials

An attempt has been made to combine knowledge gained from existing scientific publications with the country's available resources; and an intensive research program has therefore been aimed at seeking improvements in important products already mass produced in other countries.

Such products have included: polyvinyl chlorides, polymethyl methacrylates, polystyrenes, polyethylenes, polyvinyl alcohols, polyvinyl acetates, polyvinyl aldehydes, polyacrylonitrile (including fibers). Strenuous efforts have also gone into processes for neoprene rubber, butyl rubber, polyhexylamides (Nylon 6, Catalin), polyundecylamides (Nylon 11, Rilsan), polyhexyl diamides-hexyl diamines (Nylon 66), polyterephthalic acid diethyl esters (polyester fibers, Dacron), phenolaldehyde resins, urea-aldehyde resins, melamine formaldehyde resins, epoxy resins, hydroxyl-carboxylic acid resins, unsaturated polyesters, organosilicon high polymers, and various ion-exchange resins.

Basic research

Along with the development of chemical syntheses, research on the mechanism of polymerization reactions and their reaction kinetics has also begun. In the field of addition polymerization, the Research Institute of Applied Chemistry of the Academia Sinica has done extensive work on the emulsion polymerization process, and has shown that the effect of the emulsifying agent on the rate of polymerization depends mainly on the surface area of the emulsifying molecule, thus strengthening the theory of Medvedev. In condensation polymerization, Kirin University and the Research Institute of Applied Chemistry have studied hydrogen ion-catalyzed polymerization reactions both mathematically and experimentally. On the problem of three-dimensional polymerization, they derived general formulas (based on kinetic considerations) for the gel point in condensation polymerization.

In regard to the mechanism of the polymerization of polylactams, it has been inferred from actual experimental results that the process consists of three successive steps: addition polymerization, condensation polymerization, and chain transfer. In the polymerization steps, the hydrogen ion migrates, causing the substance to be doubly ionized, and initiating the polymerization.

Kirin University has studied the problem of molecular weight distribution in condensation polymerization mathematically, and has come up with results which agree with Flory's distribution. Experimental results, however, obtained at the Chemistry Research Institute disagree with Flory's conclusions. This work indicates that, in the process of chain transfer, the relatively small molecules spread much more easily in a high-viscosity system, while the relatively large molecules posses the most exchange points (amide, amine bonds).

Silicon polymers

To synthesize new types of silicon high polymers, the Chemistry Research Institute has studied the chlorination of the alkyl silanes, and the reactivity of the chlorine atom in alkyl chlorosilanes, including chlorination initiated by light and by free radicals.

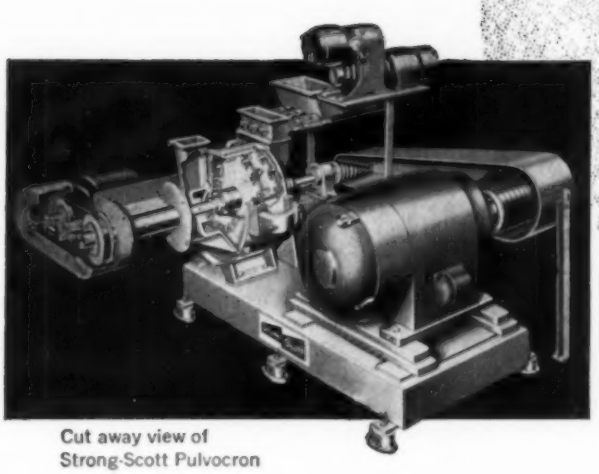
Attention was also paid to high polymers of organic tin compounds, and there was synthesized a series of polymers from acrylic and methacrylic acid-trialkyl tin esters.

Work on cellulose has been concentrated on studying the possibility of replacing wood cellulose with cellulose from other sources. Cellulose has been extracted from several grasses, and has been studied as to molecular structure, type of bonds, degree of polymerization, and behavior in the gelatinization process. The future of fibers from bagasse is also considered most favorable.

Physical chemistry of high polymers

From a study of the configuration of the double bonds, a general formula has been derived for calculating the distances between the ends of high polymer chains. Encouraging results on the solution properties of high polymers has come out of work on non-Newtonian flow, the breaking of the chains, interactions between the chains themselves and between the chains and the molecules of the solution, and their effect on the viscosity of the solution. Research also included work on the solution properties of solvent and non-solvent systems of high polymer compounds and the

continued on page 142



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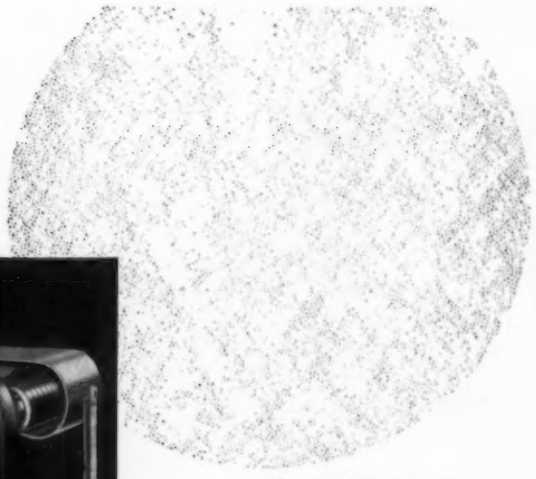

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High polymers

from page 140

second virial coefficient of the solution.

Publication program

Results of research in high polymers, whether published in the academic press, presented as theses at meetings, or compiled as reference sources, have led to publication of over six hundred papers in the field. Many higher educational institutions have established highly specialized departments of polymer chemistry. Chief academic periodicals in the field are: High Polymer Bulletin, Rubber, Rubber Techniques, and The Fiber Industry.

Condensed and adapted from a paper by Wang Pao-jen, published in High Polymer Bulletin, Peiping, China, October, 1959. The paper was kindly furnished in translation by the National Science Foundation, Washington, D. C. The material, however, is printed substantially as received, and has not been subjected to critical review either by NSF or by CEP.

A cyclohexane plant just completed by Gulf Oil will produce a high purity grade particularly adapted to the manufacture of nylon. The multimillion dollar installation is at Gulf's Port Arthur, Texas, refinery.

An analog computer installed at the University of Tennessee's Department of Chemical and Metallurgical Engineering is similar to those used at chemical processing plants. For teaching purposes, it is expected to be of great assistance in helping students to visualize the operation of plant equipment which is too large and costly for the college laboratory. The department, headed by R. M. Boarts, will also use the $33,000 computer in individual research projects by faculty members and graduate students.

Construction of a plant to produce Dicalite filteraids and mineral fillers is now underway in Ghent, Belgium. Great Lakes Carbon holds a majority interest in the newly organized company, Dicalite Europe Nord, S.A. Raw material for use in the patented filteraid process will be obtained from both European and American sources. It is expected that principal users of the filteraid will be European brewing, sugar refining, dry cleaning and chemical processing industries, who now import from the U.S.

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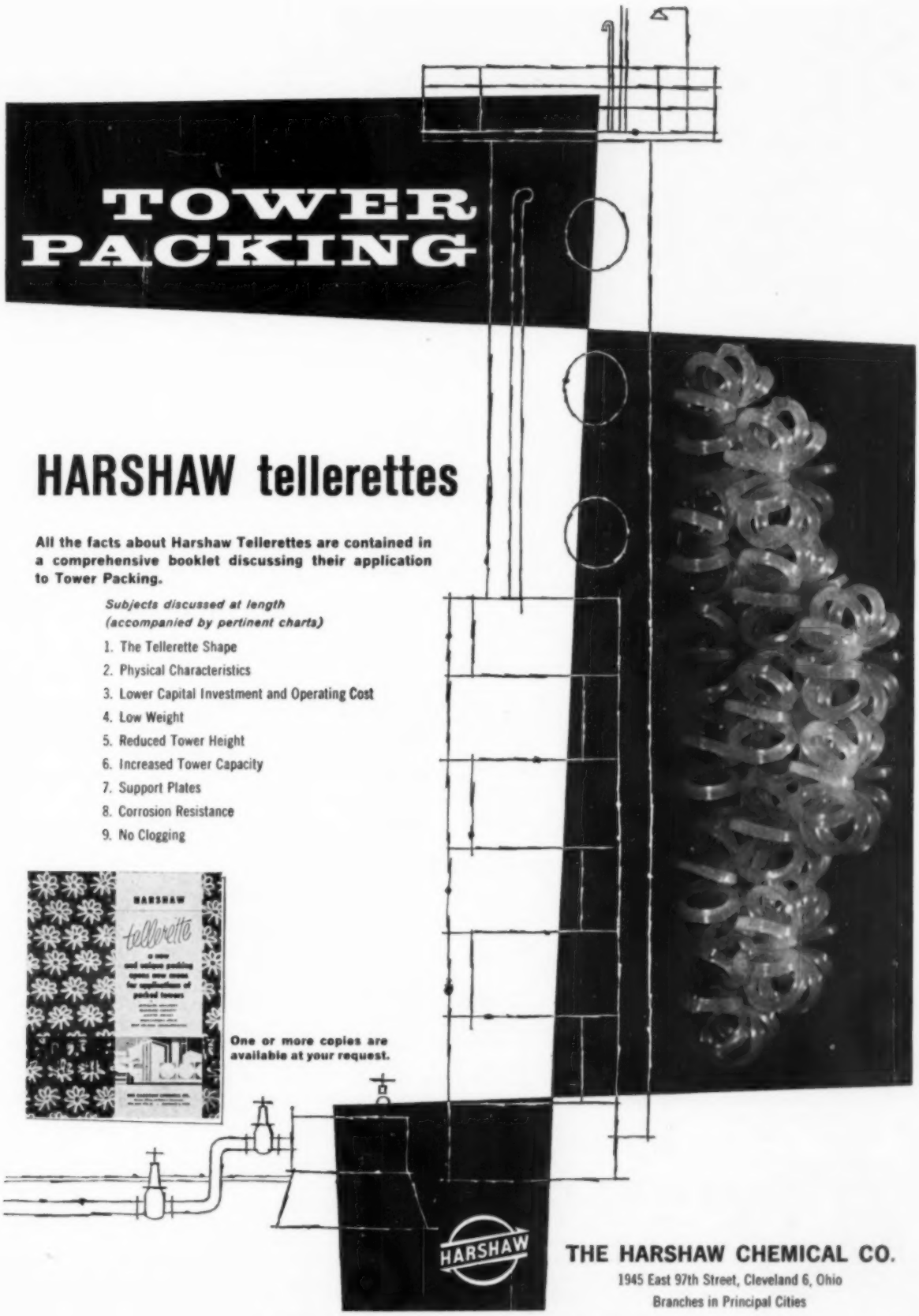

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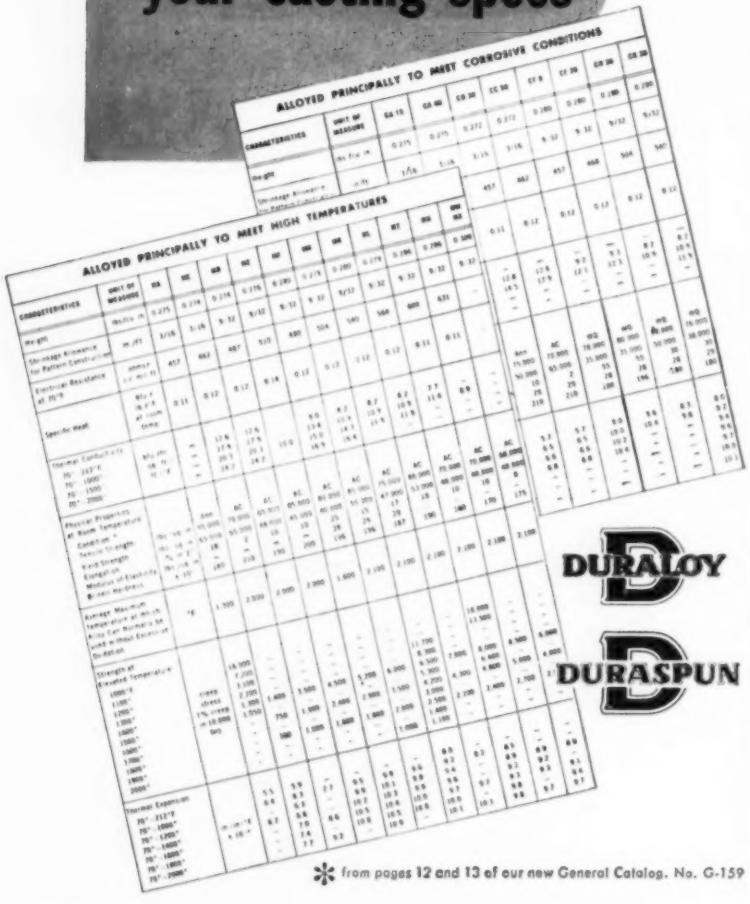

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For more information, turn to Data Service card, circle No. 100

industrial news

A chemical-nuclear report from Warsaw

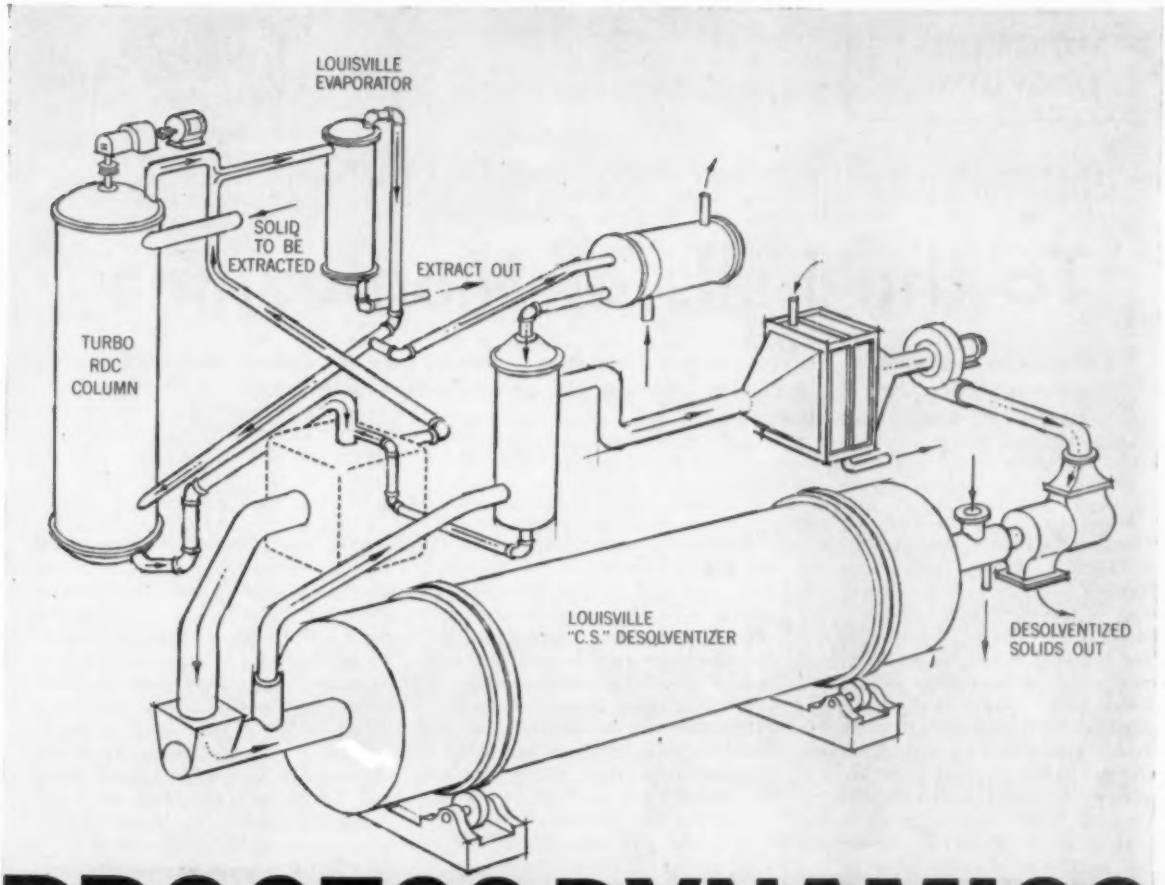
E. J. Henley
Stevens Tech.
Hoboken, N. J.

Final installment in a first-hand report begun in the November CEP.

The two sessions on *Radiation and Chemical Reactions* represented quite a potpourri. Four papers (CW/IIC/19 U.K.), (CW/IIC/27, France), (CW/IIC/68 U. S. A.) and (CW/IIIP/35, Japan) described gamma radiation induced chlorination reactions. The British and American contributions consisted of a comparison of the production of the insecticide "Gamaxane" or "Lindane" by ultraviolet and cobalt-60 radiation. It was shown that both radiation processes proceed with about the same quantum yield ~9x103, that the maximum yield of the gamma-isomer content is somewhat higher in the case of ionizing radiation, but that the ultraviolet process was more economical. The French paper concerned itself with the radiochemical chlorination of propionic acid. G values in excess of 10^5 were obtained, and the reaction was found to be independent of intensity above ~500 r/min. Chlorination may be taken to the final stage of substitution of the five hydrogen atoms in the carbon chains. It was thought that the reaction is economical and might be used as an intermediate step in the synthesis of corresponding acrylic derivatives. Also of commercial interest was the Japanese paper covering the chlorination of polystyrene, polyvinylalcohol, polyvinyl acetate, PVC and PE. The product evalutions and cost estimates were cited as being favorable.

High temperature radiation effects were covered in Russian (CW/IIC/84) and American (CW/IIC/1d) offerings. The former described the radiocracking of heptane and butane at temperatures between 25 and 500°C. For heptance, the total G value goes up by a factor of six between 25 and 200°C; most of the increase being due to a 17 fold rise in the C_4-C_{17} fraction. At 300°C a still sharper increase in yield occurs and a chain reaction sets in. Above 250°C non-linear Arrehnius plots were obtained. The American paper covered

continued on page 154



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meeting preview

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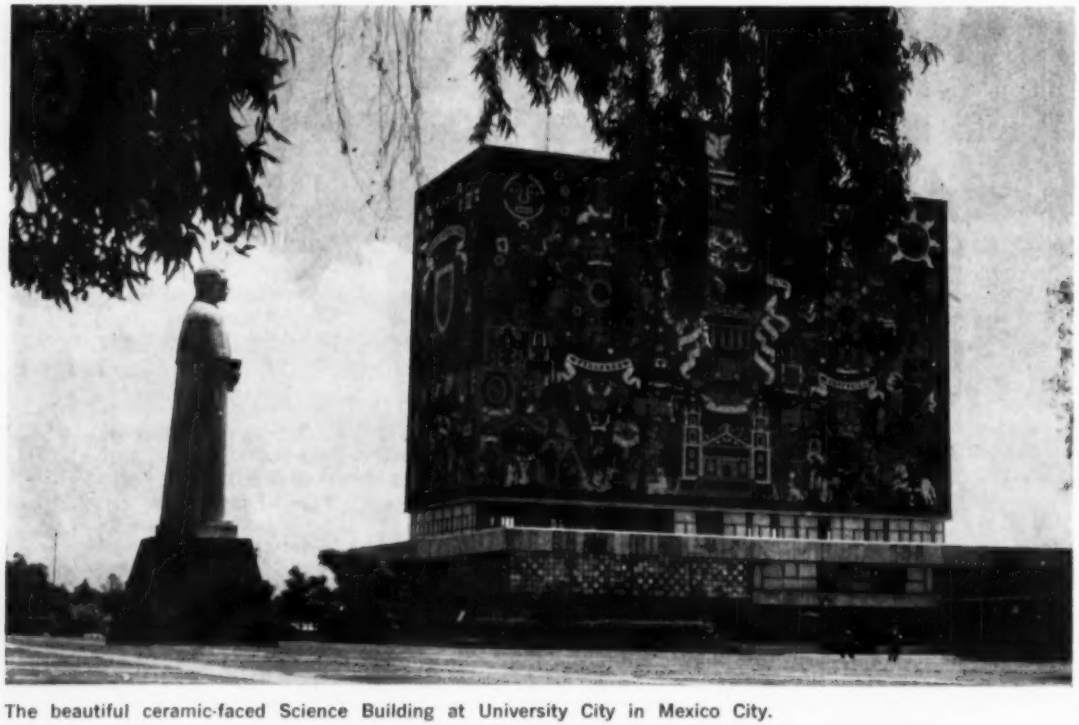
To the halls of Montezuma

Pageantry and science, the very old and newer-than-tomorrow, meet in fabulous Mexico City when modern chemical engineering vies with the ancient culture of Mexico at A.I.Ch.E.'s June 19-22 International Meeting.

THE BLEND OF THE OLD AND THE NEW, of ancient Indian cultures, later Spanish, and rising modern industrialism, is nowhere more evident than in Mexico's capital, Mexico City. In this bustling metropolis of 3 million people, a 20th century skyscraper stands in the center of the city right next to the ancient white marble domed Palace of Fine Arts. The rapid changes that are taking place make it a city of violent contrasts. One of the most remarkable technical, industrial, and manufacturing revolutions that has taken place anywhere in the world has occurred here within the last fifteen years.

In four days of conventioning, June 19-22, A.I.Ch.E. members are promised the relaxed, gracious hospitality for which our neighbors south of the border are famous; a quality unfortunately long since lost on most North American cities. The Institute and the Instituto Mexicano de Ingenieros Quimicos will jointly host the meeting, to be held at the luxurious Del Prado Hotel.

The city was founded in 1320 by the Aztec Indians. According to legend, the spot on a swampy island in the middle of a large lake was chosen for a special reason. The story goes that the wandering Aztecs had been told by the Indian prophets to found their city where an eagle with a snake in its beak was observed sitting on a cactus plant. This oldest section of the city, on what was once a lake, is sinking rapidly at a rate estimated to be one foot a year. Many old homes and churches, even the famous Cathedral itself, are tilted. After the Spanish conquests in 1521, an effort was made to drain the area.



The beautiful ceramic-faced Science Building at University City in Mexico City.

At the present time, the Mexican government is working on a multi-million dollar engineering program to halt sinkage, and to preserve the historic structures that are affected by it.

The Zocalo (main public square) is lit up on national holidays with red, white and green lights, colors of the Mexican flag. Here is the Cathedral of Mexico and the National Palace. Independence Day, the 16th of September, is a great holiday, for the Mexican people have a turbulent and recent history of struggle for an independent place among nations. While independence from Spain was won in 1821, the French held a somewhat precarious domination over the country under Maximilian, from 1863 to 1867. The modern era in Mexico can be said to have been reached in 1921, when the local dictatorship was overthrown. So the lights on the revolutionary monuments in the center of the Plaza de la Republica go on for Independence Day.

The main boulevards of the capital city are lined with colorful flowers, and the fountains scattered all over town remind one of the fountains of Rome. The city is dotted with quaint chapels and magnificent cathedrals and churches. Many majestic buildings are still standing, remnants of a highly developed civilization which goes back 4000 years before the Spanish conquerors arrived in the person of Hernando Cortes. Also standing are many palaces of the colonial era.

A tourists dream, but still typically Mexican, you will find the Mariachis strolling through the city. Fancily dressed with sombreros, they will sing and play your favorite Mexican tune for a few pesos. Throughout the streets you will find the Organilleros (organ grinders) who will also be happy to play some tunes of Mexico for you.

The National Palace of Fine Arts (this is a city of Palaces), presents operas, ballets, symphony concerts, and exhibits by world famous artists. In a land known for its artistic bent, the work of Mexico's muralists is outstanding. Some of the best known painters in the world have their work displayed in various public buildings, such as Housing, Public Works, Department of Commerce and Transports, and Public Works. In addition to being adorned with murals, the facades of many of these new buildings are decorated with mosaics. Works of art are displayed in the hotels and resturants.

In famous Chapultepec Park, Chapultepec Castle still stands, but it is now a museum. Built by the Emperor Maximilian, it was at one time a residence for Mexican dictator presidents, but present day chief executives consider themselves too democratic to live in a castle. The Park, a favorite Sunday outing place for city people, contains a zoological garden, woods, artificial lakes, and a recently built stadium which seats 18,000.

Ten minutes away from Mexico City is the city of Floating Gardens, Xochimilco, where hardworking owners of minute plots of land tend their plants. On the river, vendors float up and down displaying their wares in flower laden canoes, accompanied by the twang of guitars.

One of the more prosperous residential sections, Pedregal, (stony palace) is built on an area created by a tremendous lava flow from a volcano thousands of years ago. The gray and black volcanic rock is very porous, and takes on some grotesque shapes. For many years it was considered impossible to either plant on build on the site. But recently, new techniques of building and architecture have devised ways of making use of the volcanic rock. They also can make use of its natural formation to enhance the beauty of the section. In many cases, the volcanic rock has been utilized in walls, floors, and steps. The surrounding area has been landscaped, following the natural contours of the rock. It is now called Gardens of the Lava Flow.

A deeply religious country, Mexico counts its religious works of art by the thousands. Mexico City is the home of some of the world's greatest cathedrals, churches and chapels. Some of the most beautiful altars are to be seen, made of gold, ebony, silver, and ivory. Holy Week celebrations are held with silent processions and chants. Near Mexico City are vestiges of the older religions such as the Pyramids at San Juan de Teoti-

continued on page 148

Requirements for entry into Mexico

You must carry:

1. A Mexican Tourist Card. This can be obtained upon application to the Mexican Consulate in any principal city of the United States, and also from any Mexican Government Tourist Bureau.*

2. A document proving U.S. citizenship. This can be a birth certificate, voter's certificate, passport, or the like. Naturalized citizens should take their papers with them. U.S. citizens need no passports, but resident aliens must have both passports and alien registration cards.

3. A smallpox vaccination certificate less than three years old. This is required for re-entry into the United States.

The United States Travel Agency in Washington, D.C. has arranged special flights from major areas in the United States for engineers who may want to travel together. The Agency has offered to take care of all the details of the trip, including supplying Tourist Card application forms, for members taking one of these flights from Seattle, Portland, San Francisco, Los Angeles, Chicago, Dallas, Boston, New York, Washington, Atlanta, and New Orleans. These flights will arrive in Mexico City on Saturday, June 18. Simply request United States Travel Agency, Inc., 807 15 Street N.W., Washington 5, D.C. for necessary forms and travel reservations.

For those attending the meeting who want to stay over and sightsee a bit, U.S. Travel has also set up a series of post-convention trips, all starting Thursday, June 23. Lined up are guided tours to:

Taxco and Acapulco, $138.50 per person, ends June 26.

The Gulf Tropics, (Fortin de las Flores), Panafiel, Puebla, Cuernavaca, Taxco and Acapulco, $219.75 per person, ends July 1.

Uxmal, home of the Maya Indians of Yucatan, Merida, Chichen Itza, $268.75 per person, ends June 28.

**The Mexican Government Tourist Bureaus in the United States: 8 West 51 Street, New York, N.Y.; 27 East Monroe, Chicago 27, Illinois; 735 S. Olive, Los Angeles, California; 518 West Houston, San Antonio, Texas; Columbus Hotel, Miami, Florida; 203 Charles, New Orleans, Louisiana; 901-3 Bank of America Building, San Diego, California; 142 Mellie Esperson Building, Houston, Texas. Other offices are: 26 College, Toronto, Canada; 1255 Phillips Square, Montreal, Canada; Calle 23 No. 72, Vedado, Havana, Cuba.*

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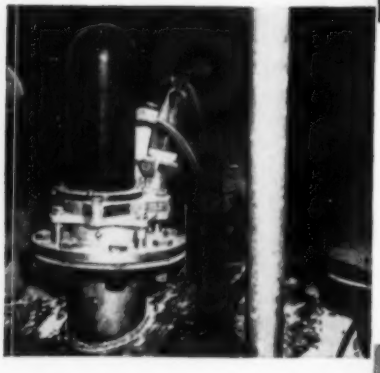

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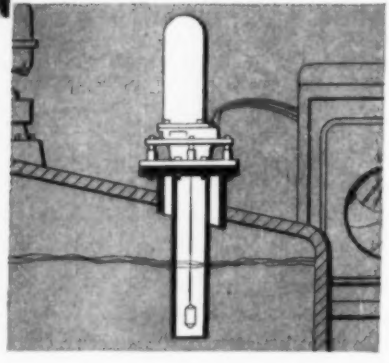

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Mexico

from page 147

huacan. From the temple of Quetzalcoatl can be seen the Temple of the Priests, and the Pyramid of the Moon. In the south, extraordinary examples of Mayan art are shown in their temples. Imposing samples of Toltec culture are in the statue of Atlantes of Tula.

Mexico City boasts two bull-rings. One, the Plaza de Mexico, is the world's largest. It seats 45,000. Bullfighting has been described as anything from a sport to a religious ritual. But for those whose taste runs in this direction, the Toreros hold forth every Sunday. During the summer, while the top Toreros are having a well earned vacation, the Novilleros, or younger apprentice fighters, can be seen. The Corridas (meets) of the professional season run from October through Easter. Another Mexican sport with an enthusiastic following is Jai Alai. Something like an elaborate handball, this fiercely competitive game is widely played.

The best examples of Mexico's famous crafts work is to be seen in Mexico City. Silver work, tooled leathers, copper and clay vessels, hand weaving, are done according to techniques handed down from generation to generation by artisans. Handweaving is best exemplified in the Indian rebozo shawls seen so often in the streets of the city, side by side with the Spanish lace mantilla.

Mexico City has a long and proud history of interest in higher education. The first University in the new world was founded here around 1550 by De Velasco. It was attended by students who came from all over the Americas to study law, the humanities, and the classics. Descendent of the original University is the modern day University City. A group of

continued on page 150

The fountains of Mexico challenge the fountains of Rome.

For more information, circle No. 9

Stabilized two-stage flame, no additives

One of a series

The burning question of cool flames

Between the brief stage of not burning and burning, many hydrocarbons react with oxygen at temperatures well below that of normal flame combustion. But the reactions are usually transient and hard to analyze. At the General Motors Research Laboratories, we have been able to investigate the *effect of chemical additives on cool preflames.*

To do this, the almost invisible cool flames are stabilized for hours in a flat-flame burner, permitting careful examination of the retardation or acceleration effects of the additives. From more than twenty additives studied, experimental results indicate that some chemicals affect combustion through the mechanism of preflame reactions. We are now accumulating new information on these additives' mode of operation. For instance: emission spectra support the conclusion that tetraethyl lead reacts with the oxygenated compounds formed in cool flames to yield lead oxide vapor. These findings of when and how lead oxide is formed are important in resolving a current controversy of science — the combustion behavior of tetraethyl lead.

Studies such as this may lead to more economical and effective means of controlling unrestrained combustion — such as "knock" in reciprocating engines. The work is typical of GM Research's effort to provide useful information for a moving America. And in this way continue to keep our promise of "More and better things for more people."

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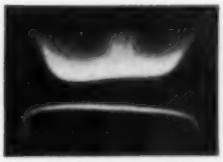
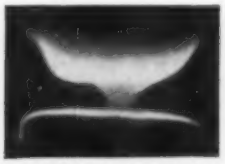
Warren, Michigan



Iron carbonyl, an antiknock



Ethyl nitrate, a proknock

Iron carbonyl retards, ethyl nitrate accelerates central portion of cool flames.

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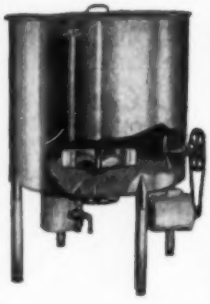

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Mexico

from page 148

A city of cathedrals and churches, both old and ultra-modern, Mexico City is a delight for the art-minded.

magnificent buildings, located in a small lava covered valley south of the city, and done in genuine Mexican architecture, the University houses 30,000 students.

At least fifteen institutions of higher learning include schools of chemical engineering in their curriculum. Of the 250 chemical engineers a year now turned out in Mexico, more than 150 come from the National University or the Polytechnic Institute. Both these institutions together have upwards of 45,000 students enrolled. The Polytechnic Institute now offers technical education in a variety of fields. Along with the engineering courses offered, are petroleum technician, biologist, textile, and business administration. Little by little, in line with the trends of the times, students are coming together from school buildings all over into the functional Polytechnical City.

Barely twenty years ago, the Mexican government initiated an economic

continued on page 152

Luxurious Hotel Del Prado, the headquarters hotel for the meeting.

FLUIDICS* AT WORK

Now . . . GLASTEEL pipe that you can field-cut

That's new Pfaudler F-C Glasteel pipe* you see being cut with a standard, dry abrasive cutoff wheel.

The F-C stands for "field cut." The pipe itself is steel on the outside for strength, borosilicate glass on the inside for corrosion resistance. Once you've cut the length you want, you thread and then fire-polish with a small, portable furnace. (Furnace available from Pfaudler at a modest cost that you will completely recover through savings in a few installations.) You finish the pipe end with a belt sander to make sure that the gasket seat is flat and the flange connection seal-tight.

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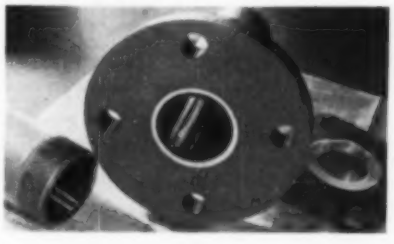
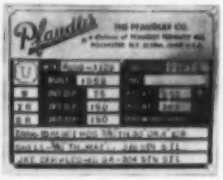
*Patent applied for



Code approval is one measure of quality in stainless reactors



This code plate on a Pfaudler stainless steel reactor tells you that every detail of construction – materials, design, workmanship – is of the highest quality.

But how can you measure quality on a non-code vessel?

At Pfaudler, both are essentially the same. Whether you require code approval or not, specify X-ray inspection, need type 304 or 316 stainless, your reactor is made in the same plants, by the same designs and under the same quality standards.

There is more than quality in the Pfaudler trademark. It also includes:

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*FLUIDICS is the Pfaudler Permutit program that integrates knowledge, equipment and experience in solving problems involving fluids.

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Mexico

from page 150

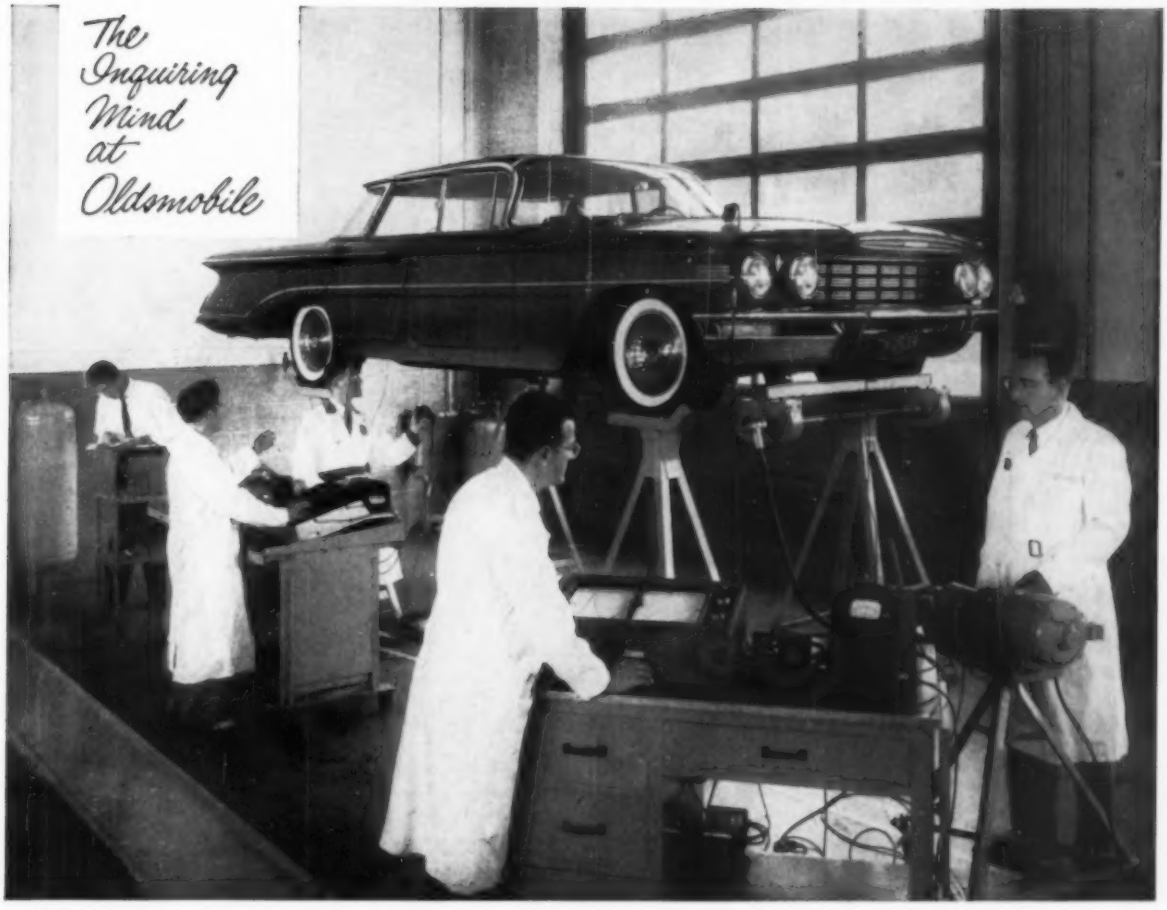
An ancient tree, a view of mountains, and modern handball courts at University City.

development program. During this period, the annual rate of increase in goods and services production was seven percent. This is twice the average percentage in the United States for the same period of time. Mexico City's population has grown more than five percent a year since 1940. While the joint efforts of the Mexican government and people have brought about fundamental changes in the economy, it must be remembered that the starting point was comparatively low. In a country that for centuries has been rooted to the soil, and in which three-fifths of the working force is still farming, industry has surged ahead of agriculture in value of output. This has shown itself in Mexico City, where government attempts to encourage new business by extending tax concessions and tariff protection have resulted in much expansion.

The chemical industry in particular has grown tremendously in ten years, most of the new chemical industry being established in Mexico City and its surrounding area. Now included in the chemical industry are caustic soda, benzol, sulfate of ammonia, sulfuric acid, and fertilizers. Petroleum production, under Petroleos Mexicanos, the organization that runs this nationalized industry, went from forty-three million barrels in 1939 to ninety million last year. Recently, a contract was signed with a U.S. firm to export up to 200 million cubic feet a day of natural gas. This operation will open another new export market. Some of the major items on the agenda for the June meeting are tours of major chemical industries in Mexico City.

All in all, Mexico City promises to be one of the biggest, best, and certainly most interesting meetings A.I.Ch.E. has ever held.

The Inquiring Mind at Oldsmobile



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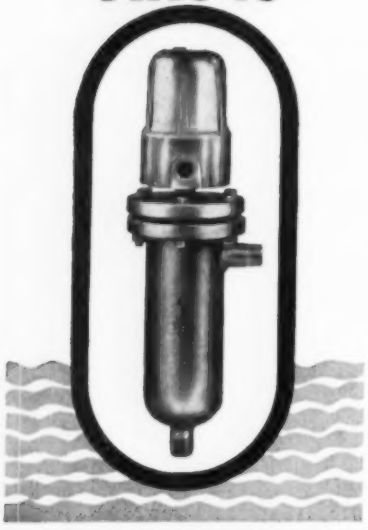

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Warsaw meeting

from page 144

among other things, the hydrocracking of anthracene at 850-860°F and 1,000-1,800psig and the water-char reaction at 1180-1200°F, and 1900-2500psig. In both cases chain reactions were obtained with G values for CH_4 plus C_2H_6 production in excess of 1000.

Oxidation effects were not overlooked, (CW/IIC/25 and CW/IIC/45, France) (CW/IIC/43d, Romania), (CW/IIB/83, Russia). The Russian paper dealt chiefly with the production of phenol from benzene and water. At 190°C the G value is 70, however the maximum phenol concentration is only 4×10^{-2} moles/liter. Engineering drawings of a small pilot plant were shown, however one surmised that this unit has not been built. The rest of the papers dealt with low temperature oxidation of hydrocarbons and the chain peroxidation of cumene at elevated temperatures.

One German paper was on the agenda (CW/IIC/50). It discussed the synthesis of dichlorophosphines and nitroso compounds by reactions such as:

$$C\,Cl_4 \rightarrow C\,Cl_3 + Cl \text{ or}$$
$$RH + P\,Cl_3 \rightarrow P\,Cl_2 + H + Cl$$

followed by

$$C\,Cl_3 + NO \rightarrow C\,Cl_3\,NO$$
$$R. + P\,Cl_2 \rightarrow RP\,Cl_2$$

Twenty-five percent yields at forty percent conversions were usually obtained. Among the products obtainable by this type of synthesis are trichloronitroso methane, dichloronitrosomethane, dichlorocyclohexylphosphine, dichlorocyclohexlarsine, etc.

Vulcanization of saturated silicon and fluoro rubbers is also being accomplished in Russia on a relatively large scale (CW/IIC/85). Experimental data was offered to demonstrate that radiation vulcanisates show better aging, better dimensional properties, and better modulus at high temperatures. The Russians proclaimed that radiation curing is an excellent process and that they are pursuing industrial testing.

Heterogeneous reactions and radiation effects on catalysts were covered in three American Papers, (CW/IIC/14), (CW/IIC/48) and (CW/IIC/67). The latter two offerings were

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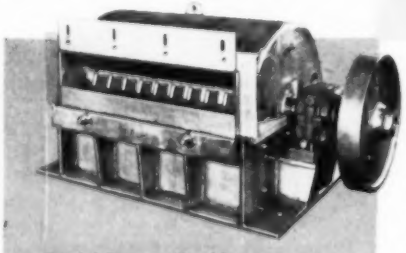

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largely in the nature of reviews of the effect of radiation on catalysts. From them, one must conclude that although large radiation effects are observed, prospects for application are rather dim, since the effects anneal out rapidly. CW/IIC/14 represented a continuation of Caffrey and Allens work on radiolysis in the absorbed state (J. Phys. Chem. *62*, 33 (1958). The results obtained show that the yield and nature of the products of radiolysis of pentane can be changed by irradiating the material in a state of absorption on a solid and that a wide spectrum of changes can be produced by empirically changing the nature of the solid. A silica surface seems to have a unique facility for inducing isomerization while sodium cobalt zeolites on the other hand give uniquely high G values for hydrogen production.

Sterilization of foods and drugs also found its place on the agenda.

1. Foods—The only paper on this topic was a lengthy American Status-of-the-Field Review (CW/S/17). Among the major points raised were

a) It will be several more years until the completion of tests which will make the public sale of irradiated foods possible.

b) The quality of many irradiated food products is being constantly improved. Off-flavors are now hardly noticeable except to people with sensitive palates.

c) Radiation preservation is potentially an aid to the undernourished peoples of the world and may ultimately lead to a decrease in the cost of food merchandising.

d) "Brown and serve" meats are "within our grasp in the near future."

Discussions following this paper accentuated the fact that many foods technologists, particularly the European groups, find the general prospects of food sterilization by ionizing radiation somewhat less hopeful. There was some banter about the ability of radiation to aid in maturation of cheeses and whiskey (particularly vodka). Many discussants felt, in addition, that underdeveloped countries might more profitably invest in refrigeration equipment than irradiators.

Two papers were presented. One was a rather minor effort by the Hungarians which related the fact that distilled water can be sterilized by gamma radiation (CW/IV B/44d), the other paper was an account of Ethicon's radiation sterilization production line, (CW/IV B/63). Ethicon has been sterilizing over 80% of its sutures this way for eighteen months. #

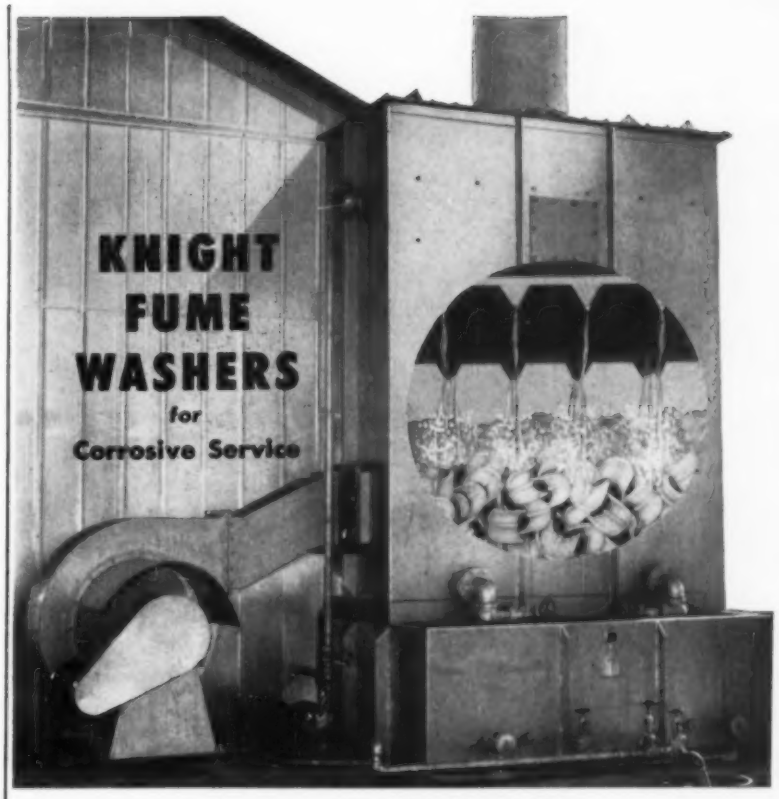

Photo Courtesy Summerill Stainless Tube Div

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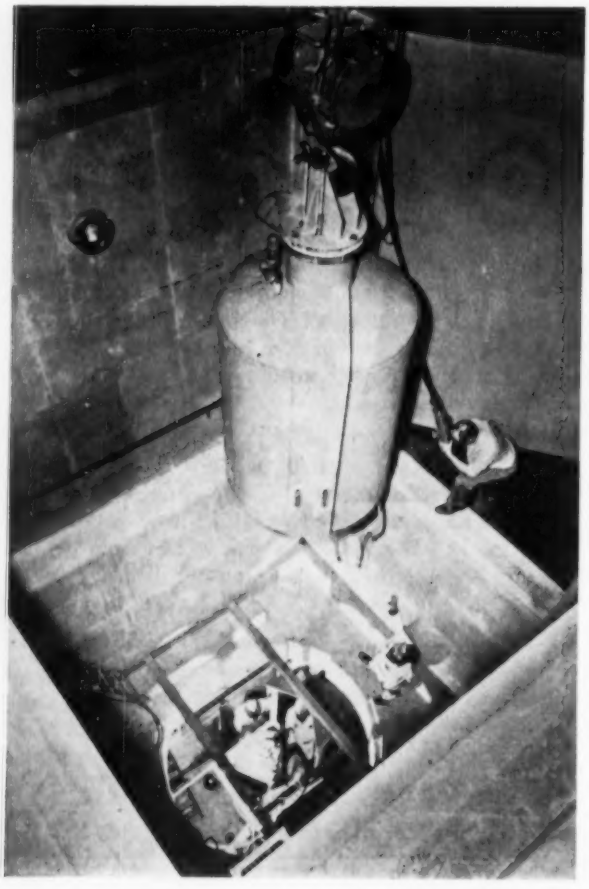
AIChE Petrochemical and Refining EXPOSITION

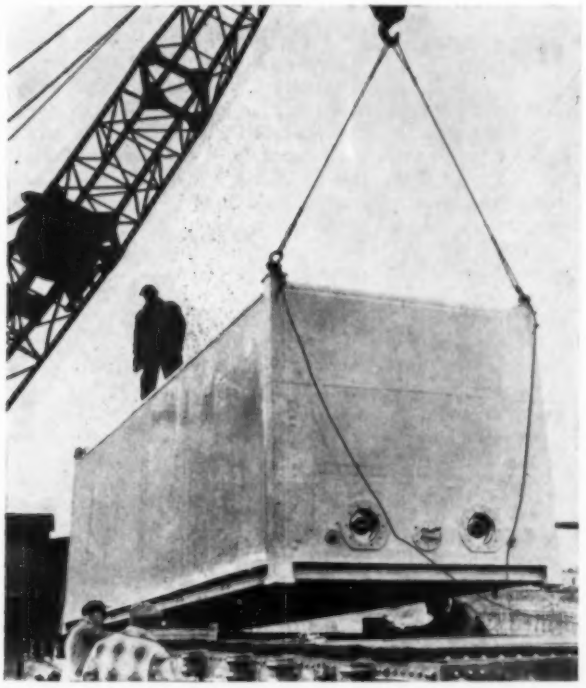
Palm treed arcades in New Orleans . . . site of the Petrochemical and Refining Exposition to be sponsored by the American Institute of Chemical Engineers in conjunction with National A.I.Ch.E. Meeting to be held in the Mardi Gras city from February 26 through March 1, 1961. The Exposition will be the keynote of several technical sessions on applications of chemical engineering in the production and processing of petroleum and petrochemical products. The Exposition and the many special petroleum symposia will serve to emphasize the growing interdependence of these industries and of chemical engineering practice along the Gulf Coast.



A Hughes Aircraft Co. scientist examines the heart of the new "solid state radiation detector" claimed to have wide new uses in space exploration, industrial processes, basic nuclear research, and other fields, and said to be "1000 times faster than previous detectors."

This two-million volt electron beam generator has just been shipped to the Max Planck Institute in Mulheim, West Germany. Manufacturer is General Electric.

cep camera



Workmen load a completed epoxy-glass fiber cargo carrier on a railroad flat car. Construction of the carrier allows it to be tilted for discharge. Photo courtesy Union Carbide Plastics.

Excavation for the new United Engineering Building has been completed on the east side of the site, installation of reinforced forms is advanced.

Not a snow-storm scene but the inside of a Canadian Pacific Airlines hanger in Vancouver during a test of a new foam-water fire protection system designed by "Automatic" Sprinkler Co. of Canada. Test was a big success.

local sections

Space travel problems, fluid agitation theories in spotlight

Research on rocket propulsion systems is far ahead of research on the biological systems which will be necessary for extended, manned space travel, Arthur E. Humphrey told the **Philadelphia-Wilmington Section** (*Milton W. Harper*) in January. To indicate the amount of research still required in the field of biological systems, Humphrey, associate professor of chemical engineering at the University of Pennsylvania, enumerated twelve major immediate problems. These must be solved in designing a closed cycle biological system for space travel, he said. Included are a suitable food and water supply, a CO_2 adsorption system, heat removal, water removal, body waste disposal, and probably an air flushing system. For future manned space travel, closed biological cycles must be able to operate for periods varying from less than two weeks for trips to the moon and near planets, to more than a year for trips to distant planets.

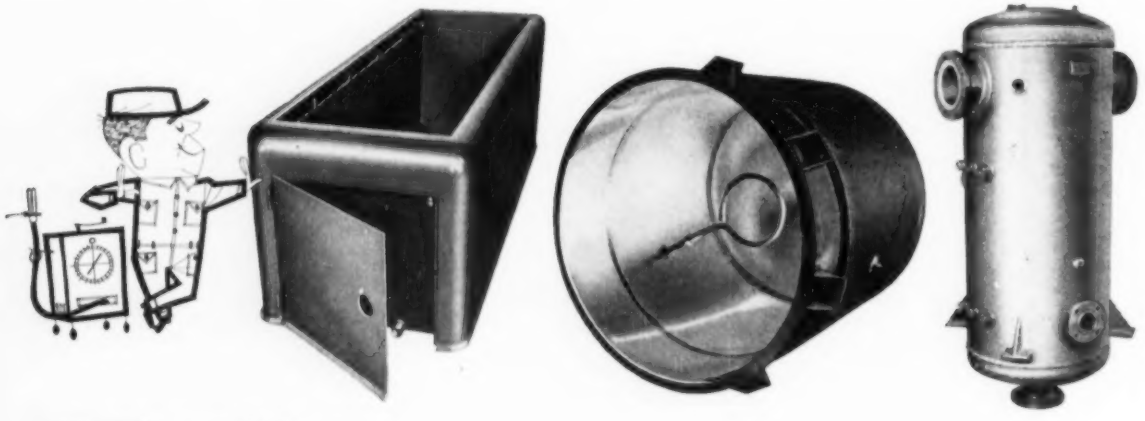
The present day concept of a vehicle for manned space flight provides only a small space capsule. But in reality, an area equivalent to approximately two thirds of the total rocket will probably be required for the biological systems that can support life for extended periods in outer space. This concept contrasts with current thinking by propulsion engineers, who now use the major proportion of today's rocket for the propulsion system.

A rapidly growing world population in the face of a slowly improving food supply is a noteworthy second factor. Present research in the space field will provide much valuable information which is applicable to this problem. Food factories operating on mass cultures of living cell tissues could be designed by biological engineers to produce large quantities of essential nutritional elements.

Fluid agitation

If engineers paid closer attention to the design of agitation equipment, and made proper use of mixing experimentation and data, costs could be reduced by ten percent. Chemical process plants spend $70 million annually for agitators, or five percent of total equipment costs, Robert L. Bates, vice president and technical director, Chemineer Corporation, told the **Louisville Section** (*Joseph E. Mosel*) in January.

Engineers often enter an area of mystery when they are called upon to design an agitation system. As a result, many systems are not designed for optimum economy and performance. One reason is that we may develop our pet theories about agitation, and these may not account for the complete facts. For example, the well known mixing Reynold's number is not necessarily a good criterion upon



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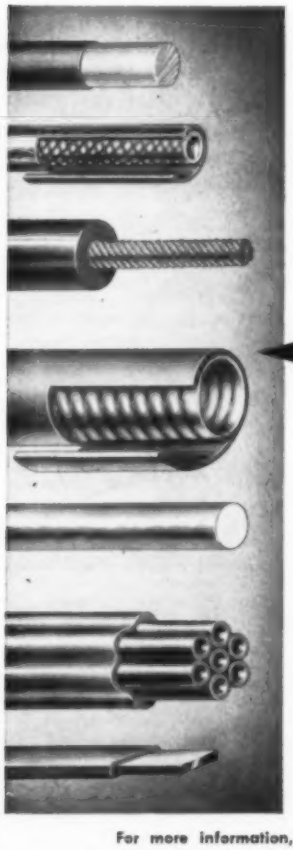
which to judge agitator performance, or base calculations. As defined, it describes agitation intensity only on the immediate vicinity of the impeller. What is needed is a systems Reynold's Number which describes the state of the entire vessel. We should not assume that constant HP/Unit Volume will mean equivalent agitation when we scale up from small equipment. Tests should be made in at least two vessels with sizes ranging in a 10:1 ratio. A log log plot of HP/Unit Volume vs. Volume will check the validity of our assumption. These tests can warn us of impending agitation difficulties.

In another talk on the subject, this time before the **Central Ohio Section** (*James D. Jackson,*) Bates set out to further dispel the "sacred cow theories of fluid agitation", as he termed the disagreements brought about by pet ideas in the field. These differences of opinion, while brought about by the fact that the technology itself is difficult to define, make it all the more necessary to clarify the concepts of agitation. Practically all impeller operation, Bates claimed, can be done with two or three. The standard 3-blade impeller is used up to 300 centipoise, a turbine centrifugal type up to 100,000 cp and the paddle type only at extremely high viscosities.

The tremendous strides that have been made in the last fifty years by the professional engineer in gaining acceptance, were traced by Wilhelm Hirschkind. The adviser to the president of Dow Chemical on foreign chemical industrial operations addressed the **Northern California Section** (*William B. Hauserman*) in November. Hirschkind's own career closely parallels the development of the field, for he was a student under Fritz Haber in Germany. The process of synthesizing ammonia directly from nitrogen and hydrogen discovered by Fritz Haber fifty years ago shortly replaced the only other existing method of fixed nitrogen production, oxidation of atmospheric nitrogen by arc discharge. It has since grown from the 200 cc/hour production rate of Haber's pilot plant to a major industry producing around 40,000 tons a day throughout the world.

One of a team of engineers assigned to the job of improving the uranium recovery rate at Phillips Petroleum Robert A. Koble described his experiences to the **Bartlesville Section** (*W. C. McCarthy*) in October. Also, part

continued on page 160



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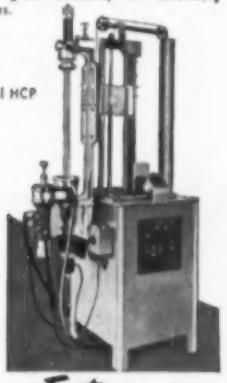

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local sections

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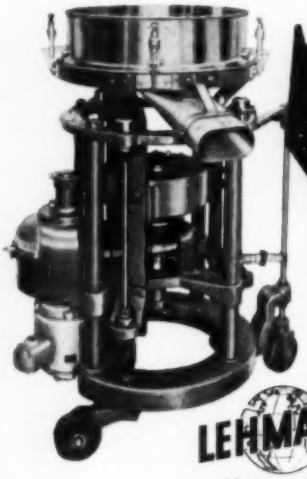
of their task was to reduce the cost of processing chemicals. The milling process at the company's Ambrosia Lake, mill in New Mexico was described. The mill consumes 2000 tons a day of uranium ore, and produces 10,000 lb./day of sodium diuranate or yellow cake by the carbonate leach process. Uranium solubles losses in water leaving the plant were within the design premise of 3-4 percent.

Several improvements in the filtration step of the ore slurry from the soluble uranium reduced soluble losses from 2.0 to 1.5 percent. Further savings were obtained by using cheaper processing chemicals through optimizing of feed back of pregnant leach waters. Still more improvements over the 92-93 percent efficiency of the leaching steps are expected.

In summary, Koble gave five general rules for optimizing operations in commercial plants. They are good organization, thoroughness, openmindness, honesty and good salesmanship.

Also meeting

Speaker at the September meeting of the **Rocky Mountain Section** (*Robert E. Gustafson*) was retired Brigadier General J. H. Rothschild. The general is of the opinion that the use of chemical agents in war is the closest approach to humane warfare . . . Jerry McAfee, vice president of A.I.Ch.E. spoke to the joint meeting of **New Jersey and North Jersey Sections** in November. He made a fundamental analysis of what the A.I.Ch.E. is all about and how individuals profit from activities of the national organization. Plant lay-out, the high road to low cost maintenance, was Henry P. Evans', topic at the **Southwest Washington** (*H. E. Hendrickson*) November meeting. Hendrickson is staff consultant for the C. F. Braun Company. . . . John O'Neil spoke to the **Pensacola Section** (*J. B. McKoy, Jr.*) in January on The Development and Use of Phosphate Insecticides. . . . The **Idaho Section** (*E. E. Erickson*) heard Elizabeth M. Whitener, associate chemist at Phillips Petroleum, on pure foods, drugs and cosmetics. Occasion was the December meeting. . . . The arduous job of establishing and preserving a small business was discussed by Elmer A. Fike at the **Charleston**



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Section (*G. O. Walker*) in October. Fike heads his own firm, Roberts Chemical, in Nitro, West Virginia. . . . The role of process economics in chemical engineering and in the industry was considered by John Happel, head of the chem engineering department at NYU, at the **East Tennessee Section** (*James E. Williams*) in November. . . . Reaction kinetics was chosen by R. J. Hengstebeck for his November talk to the **Rochester Section** (*Robert L. Cramer*). Speaker at the **Alton Wood River Section** (*J. G. Huddle*) in November was J. N. Holsen, chemical engineering professor from Washington University. Subject: Applications of shock tube reactors in chemical processing and other industries. . . . The rapidly increasing interest in analog computers was Bill McKinley's topic as featured speaker at the **Nashville Section** (*F. L. Creamer, Jr.*) in November. . . . Chemical engineering students from nearby schools joined the **Boston Section** (*Ralph L. Wentworth*) at the Museum of Science for the Ichthyologists November joint meeting with ASTM. Frank L. LaQue, head of ASTM, addressed the group on corrosion. . . . What's new in secondary school education was the timely topic chosen by the **Western Massachusetts Section** (*D. M. Sullivan*) for its November joint meeting with the Engineering Society of Massachusetts. . . . Annual student night at the **Baltimore Section** (*John W. Holtz*) heard Donald Katz on progress in the nuclear fields. He compared the U.S. nuclear program with that of other countries, emphasizing that our approach has been to concentrate not one particular type of reactor, but to work in the whole field. . . . The **South Texas Section** (*W. G. Domask*) went on a tour through the Houston plant of General Foods in December. The gathering also heard Percy Foreman, nationally known civil rights lawyer, on the civil liberties field. . . . How the Senate conducts business was Senator Clifford Case's talk to the **New Jersey Section** (*E. M. Powers*) in December. . . . A demonstration of current techniques for reading improvement was seen by the **Alton Wood River Section** (*J. G. Huddle*) in December. . . .The impact of the oil industry on the American economy was the **Coastal Georgia Section's** (*J. M. Eagan*) November meeting topic. Mark Hopkins, plant manager, Amoco's Yorktown, Virginia, refinery, was the featured speaker. . . . A panel of four **Nashville Section** members discussed

continued on page 163

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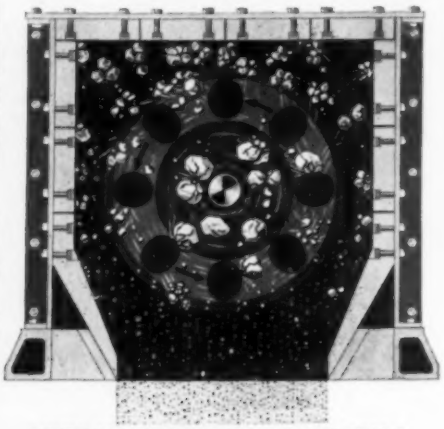

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local sections

from page 161

the role of the chemical engineer in industry at the Annual Orientation Night for Vanderbilt Senior students in December. . . . **Lewis E. Fritz**, American Society for Clinical Hypnosis, gave the December **Boston Section** meeting a briefing on the use of hypnosis in medicine. . . . A tour of the Laclede Steel Alton plant was on the agenda for the **Alton Wood River Section's** (*J. G. Huddle*) January meeting. . . . The editor and publisher of Audio Magazine spoke on Hi-Fi today to the **New Jersey Section** (*E. M. Powers*) January meeting. . . . A representative of Westinghouse's Atomic Energy Division addressed the **Western New York** (*Reed Garver*) joint session in January with ASME. Commercial atomic power plants was his topic. . . . Missile technology and application of plastics to missiles was described by J. H. Lux, president, Haveg Industries, to the **Pittsburgh Section** (*G. H. Haddad*) in January. . . . The **Western Massachusetts Section** January meeting (*J. C. Kelley*) heard George E. McCullough, GE, on chemical plant site selection. . . . An authority on water conservation problems, Victor Bouldin, spoke to the **South Texas Section** (*W. G. Domask*) in January. . . . Five factors affecting success on the job were listed by Cary Wagner, consulting chemist, at the **Bartlesville Section** (*W. C. McCarthy*) in November. They are: fitness for work, ability to get along with others, and plan and execute a program for oneself, and loyalty.

The ninth edition of Chemical Engineering Faculties has just been published. The 66 page annual lists a variety of information about the Departments of Chemical Engineering in the United States and Canada for 1959-60. Some facts included are whether the department is accredited, types of graduate work offered, and names of departmental faculty and placement officer. Prepared by the Institute's Chemical Engineering Education Projects Committee, copies are available on request. Write to A.I.Ch.E., 25 West 45th Street, New York 36, N. Y.

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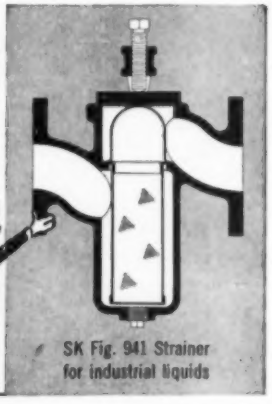

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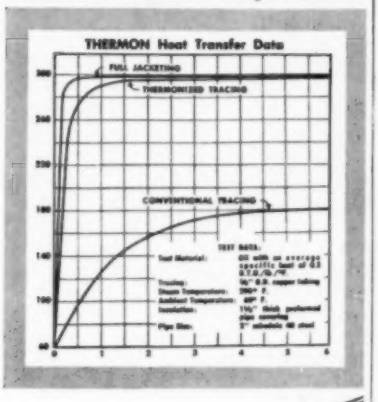

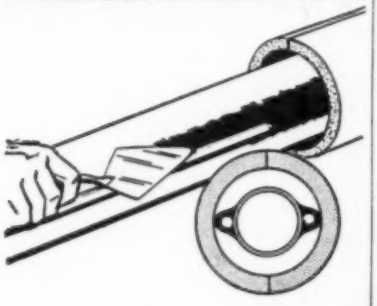

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Harry D. Smith has been named manager, Goodyear Tire & Rubber's International Synthetic Rubber Projects. Until recently, Smith was project manager for the company synthetic operations with offices at Houston, Texas. He succeeds the late George R. Lyon, who died in November.

Donald W. Oakley has been appointed vice president of Metal & Thermit. Oakley who joined M&T in 1947 as a research chemist, will retain his present assignment as general manager of the coatings Division. He is a past chairman of the New Jersey Section of A.I.Ch.E. and a current member of the national program committee.

R. Curtis Johnson takes over the post of associate manager, Process Analysis Department, Thompson - Ramo - Wooldridge. He taught chemical engineering for ten years before coming to the California firm, in 1958. Johnson is the author of 25 technical papers and co-author of *Stoichiometry for Chemical Engineers.*

Jonathan P. Rogers becomes production superintendent of Monsanto's, Monsanto, Tenn., plant. He was formerly phospbate production supervisor at the Tennessee facility.

John R. Hodson assumes the post of associate director, Development Department, Texas Butadiene & Chemical, with offices in New York. He has spent the last three years with the company on process economics and development work.

Edward G. Lang has been promoted to plant manager of Stauffer Chemical's Hammond, Indiana, plant. Joining the company in 1952, he was until this change in post, assistant superintendent in charge of production of the Consolidated Division, Texas plant.

continued on page 166

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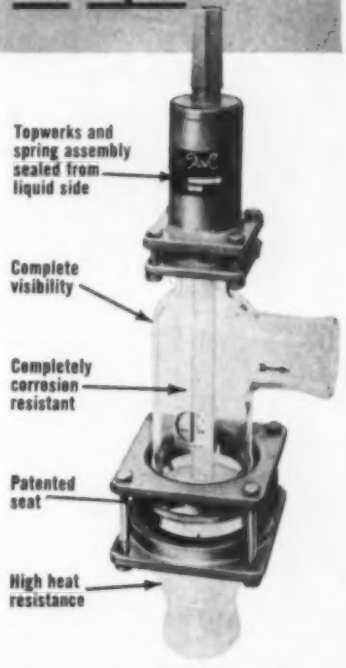

A completely new concept in relief valve seat design plus *Pyrex & Teflon Construction for the added advantages of full visibility and corrosion resistance Seat pressure is completely independent of spring load. Valve reseats after venting without labor or material cost of rupture disc replacement. Ideally suited for both pressure and vacuum relief. Seals against liquids and gases. Use with liquid lines, with reactors and vessels of all types. Available in other materials of construction. Ask us for Bulletin RV-1.

*T.M., Corning Glass Works

A NEW LINE OF CORROSION RESISTANT FILTERS

Permanent filter element offers maximum particle retention with very high flow rate. Porosity range, one to 100 microns. Use for sterilization, clarifying, polishing. Pyrex & Teflon construction for visibility and high temperature applications. Write for Bulletin FPT-2.

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CHEM FLOW CORP.
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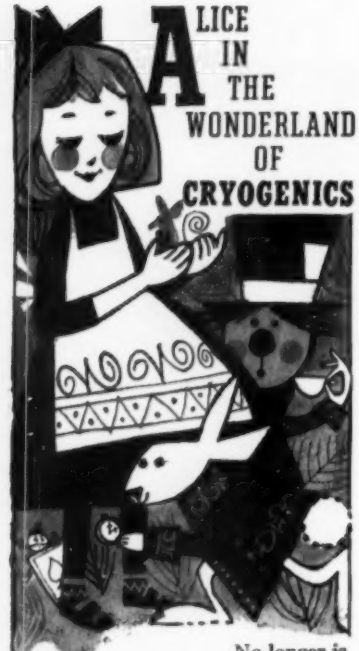
For more information, circle No. 82



No longer is CRYOGENICS a fantasy . . . nor do you need a rabbit's hole to reach a world of wonderment. ♠ RYAN's pre-eminence in the Field of CRYOGENIC EQUIPMENT assures your greater existence in a realistic world. ♦ Technical research and development of your equipment requirements by RYAN is the fulfillment of your greatest expectations. ♥ The 106,000 SCF liquid oxygen customer station complete with dual final line regulators, economizer and automatic pressure building system would be the center of attention at any Tea Party. ♠

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CRYOGENIC DIVISION
DEPARTMENT F
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Write Today for Technical Literature

For more information, circle No. 17

people

from page 165

Howard F. Voight has been appointed president of Stedman Foundry and Machine. He comes to the United Engineering and Foundry subsidiary after more than twenty years with the parent firm.

Reassignments and promotions at Monsanto Plastics Division at Texas City, Texas:

J. M. Chamberlin, plant manager, **W. J. Burkett,** and **E. John Mackie** senior engineering supervisors, **R. W. Kienker** is assistant director of engineering, and **M. A. Vela** is engineering supervisor. At the William G. Krummrich Plant, Monsanto, Illinois, **H. C. Carder** and **Paul E. Heisler** have been appointed general manufacturing superintendents. At the Inorganic Chemical Division plant at El Dorado, Arkansas, **J. E. Kinard** has joined the Engineering Department, coming to them from the faculty of Tulane University.

Donald J. Kridel, speaking at a meeting of Mid-West Industrial Photographers held in Davenport, Iowa, in January, presented the technical story of fine grain development of black and white film. Kridel, head of the development staff in Kodak's Photochemicals Division in Rochester, New York, also described recent research into methods of preparing specialized developers to increase sharpness in the final image.

William G. Dedert has been named manager of Research and Development, Swenson Division, Whiting Corporation. Dedert has been with the Illinois firm since 1946 when he graduated from Rose Polytechnic Institute. He is succeeded as manager of the Pulp and Paper Department by **J. N. Brown.** Brown was formerly with the Chicago sales office.

Mott Souders, Jr. director of oil development at Shell Development's Emeryville, Research Center, has been elected a fellow of the New York Academy of Science. According to Academy officials, election to Fellowship is conferred upon a limited number of members who have done outstanding work toward the advancement of science.

A Southern Research Institute re-

NEUTRONS
GAMMA RAYS
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are accurately measured by the Landsverk Model L-49 200 MREM Thermal Neutron Dosimeter

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DEWPOINTER

Any shop man can quickly and accurately read dew points with the Dewpointer. It is the only instrument that lets you see the fog in a sealed chamber under controlled conditions. Compare this fast, positive method with attempts made to tell exactly when fog forms on a mirrored surface. Completely self-contained, requires no external coolant or auxiliary apparatus...operates on enclosed battery or AC. Available in three ranges for dew points between —20° F. and room temperature, from —80° to 0° F. and —80° F. to room temperature.

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Send for Dewpointer bulletin. Tear out this ad and send on your letterhead to: Illinois Testing Laboratories, Inc., Room 573, 420 N. LaSalle St., Chicago 10, Illinois.

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search project to study the feasibility of removing calcium and magnesium from sea water by chelation and complex-formation is under the direction of **E. W. Lang** and **R. E. Lacey**. Lang is head of the chemical engineering section and Lacey is senior chemical engineer. The research is sponsored by the Office of Saline Water, U.S. Department of the Interior, as part of its over-all program to develop low cost methods of producing consumable water from sea water.

Clarence L. A. Wynd takes over as general manager of the Kodak Park Works, Eastman Kodak. A company vice president, he moves up from the post of assistant general manager. Wynd succeeds **Ivar N. Hultman,** who retired after nearly 41 years with the Rochester company.

R. E. Cairns has been elected to the board of directors of Hercules Powder. Director of research for the company since 1955, he began his career with Hercules in 1934 as a research chemist. Cairns is chairman of the General Sciences Advisory Panel and a member of the Defense Science Board.

Charles C. Brewer (left) has been named assistant plant manager at Foster Grant's Baton Rouge, La. Chemical plant. **James H. Mayes** became technical superintendent in another company move, part of its program of making the Louisiana operation a separate chemical division.

Roger T. Johnson has joined the Richmond Laboratory, California Research, as a research engineer. **Lawrence W. Jordan, Jr.** is a new member of the Oil Recovery Division at the La Habra Lab as a research engineer. He recently completed work on his Ph D at Ohio State University.

James D. McNitt has been named executive vice president of Bristol Laboratories. McNitt, who came to Bristol in 1944 from the faculty of MIT, has served as a vice president and general manager of the Syracuse firm since 1958.

O. D. Myrick, Jr. has been appointed director of development planning for the Grace Chemical Group. Myrick was with Grace's Davison Chemical

continued on page 168

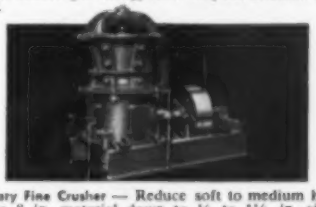
NO MAJOR REPAIRS IN 25 YEARS*

Sturtevant Construction Assures Long Mill Life at Top Loads

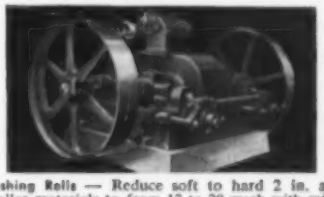
Sturtevant crushing and grinding machinery answers the long life top-load production problem for medium to small size plants. Many Sturtevants have been operating above rated capacities for more than 25 years, and *without a major repair.*

"Open-Door" design gives instant accessibility where needed — makes cleanouts, inspection and maintenance fast and easy. Machines may be set up in units to operate at equal quality and capacity.

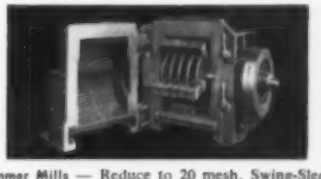
Jaw Crushers — Produce coarse (5 in. largest model) to fine (⅛ in. smallest model). Eight models range from 2 x 6 in. jaw opening (lab model) to 12 x 26 in. Capacities to 30 tph. All except two smallest sizes operate on double cam principle — crush double per energy unit. *Request Bulletin No. 062.*



Rotary Fine Crusher — Reduce soft to medium hard 3 to 8 in. material down to ¼ to 1¼ in. sizes. Capacities up to 30 tph. Smallest model has 6 x 18 in. hopper opening; largest, 10 x 30 in. Non-clogging operation. Single handwheel regulates size. *Request Bulletin No. 063.*



Crushing Rolls — Reduce soft to hard 2 in. and smaller materials to from 12 to 20 mesh with minimum fines. Eight sizes, with rolls from 8 x 5 in. to 38 x 20 in.; rates to 87 tph. Three types — Balanced Rolls; Plain Balanced Rolls; Laboratory Rolls — all may be adjusted in operation. *Request Bulletin No. 065.*



Hammer Mills — Reduce to 20 mesh. Swing-Sledge Mills crush or shred medium hard material up to 70 tph. Hinged-Hammer Pulverizers crush or shred softer material at rates up to 30 tph. Four Swing-Sledge Mills with feed openings from 6 x 5 in. to 20 x 30½ in. Four Hinged-Hammer Pulverizers with feed openings from 12 x 12 in. to 12½ x 24 in. *Request Bulletin No. 084.*

**Reports Manager W. Carleton Merrill concerning Sturtevant Swing-Sledge Mill at James F. Morse Co., Boston.*

STURTEVANT
MILL COMPANY
135 Clayton Street, Boston 22, Mass.

For more information, circle No. 27

FOR

PURE WATER

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ATOMIC INDUSTRY
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WATER CONDITIONING
EQUIPMENT

- Deionizers
- Ion Exchangers
  manual and automatic
  regeneratable and ex-
  pendable units.
- Chemicals
- Engineering
- Consulting
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Since 1950, Elgin has specialized in meeting high quality water requirements in the atomic field. From coast to coast and on the high seas, nuclear engineers have been utilizing Elgin experience and equipment to meet the needs for high purity water.

Elgin multi-column and mixed-bed Ultra-Deionizers are giving outstanding service in furnishing high quality makeup water and in purifying recirculating or coolant water for primary and secondary loops in atomic reactors.

Atomic laboratories, too, have standardized on Elgin water conditioning equipment for their high quality water supply.

Let us put our experience to work in solving your water conditioning problems. Write for Deionizer Bulletin 512.

Nuclear Applications Dept.

ELGIN SOFTENER CORP.
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Elgin, Illinois
Water Conditioning Since 1908

For more information, circle No. 25

people

from page 167

Division for eighteen years in various positions in research and development.

Charles H. Hacker moves into the newly created post of chief engineer, industrial filters, for Pall Corporation, Glen Cove, New York.

H. W. Helmke is a new member of the technical staff of Esso Research Laboratories, Baton Rouge, La.

James R. Anslow takes over the position of senior research chemical engineer at Jefferson Chemical's Austin, Texas, research lab.

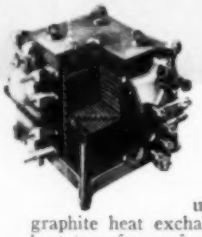
Bryson Filbert has been appointed chemical products adviser to the Refining Coordination Department, Standard Oil of New Jersey. Filbert was formerly manager of manufacturing for International Petroleum Ltd., an affiliated company in Columbia, South America.

Joseph M. Smith, chairman of the Chemical Engineering Department at Northwestern University, delivered the annual Chemical Engineering Lecture Series at the University of Illinois in November. His subject was Heat Transfer in Reacting Systems and Burning Rates of Solid Propellants. The series, sponsored by the University's Chemical Engineering Division and the local ACS chapter, each year brings in an outstanding chemical engineer to deliver a series of lectures.

William H. Darnell was honored recently by the Philadelphia - Wilmington Section for his accomplishment in receiving a Best Presentation of Paper Award from A.I.Ch.E. Darnell delivered a paper on *Drop-Size Distributions from Pressure Nozzles* at the National Meeting of the Institute in Cincinnati last year. It was written jointly with W. R. Marshall, Jr., University of Wisconsin. Darnell, formerly research supervisor of Du Pont's Polychemical Department at the Experimental Station, is now at the company's Victoria Works. He took over the post of research supervisor for nylon intermediate process development.

"STANDS UP *in the tough applications*"
. . . says still another user

'Delanium' Graphite
BLOCK TYPE
HEAT
EXCHANGERS



PERFORMANCE REPORT 220

OPERATION:—Cooling 73% sulfuric acid from 280°F to 140°F., following dilution from 93%.

UNIT:—'Delanium' Graphite Heat Exchanger Model 100/100 M.

PERFORMANCE: Customer reports complete satisfaction. Previous operation required purchase of 78% acid which was diluted to 73% in open vat. Freight savings, realized when purchasing 93% acid, paid for the 'Delanium' installation in 6 months. In addition, a hazardous acid mist problem was eliminated.

USER: Midwest superphosphate fertilizer manufacturer.

The denser grade of graphite in 'Delanium' exchangers provides greater resistance to corrosion and mechanical abuse, Block-type design can handle operating pressures up to 200 psig against 40 to 50 psig for most other types of graphite heat exchangers. Occupies ⅓ the space of other units of comparable heat transfer surface. No internal gaskets between process and service streams; no floating heads, no packing. Sixteen models, 4 to 500 sq. ft. Temperatures to 360°F. and higher. Heaters, coolers, evaporators, condensers . . . for pharmaceuticals, agricultural chemicals, acids, organics and chlorinated solvents.

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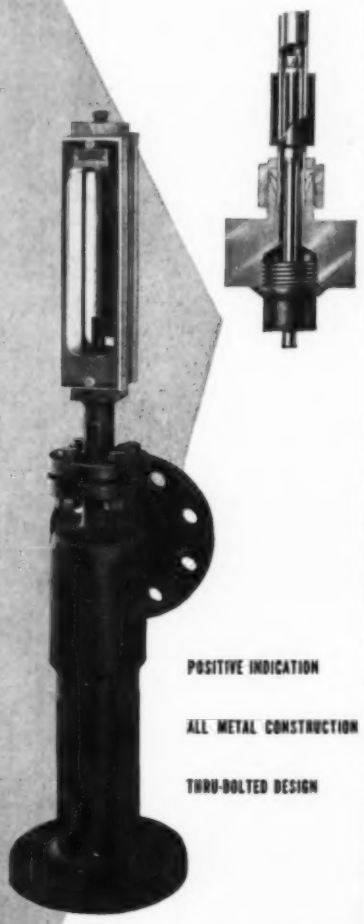
AR-MET ROTAMETER

. . . takes practically *all* fluids off the hard-to-handle list



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ALL METAL CONSTRUCTION

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Working with highly penetrable fluids . . . high temperatures, high pressures? Then, Brooks Ar-Met Rotameters are made to order for you.

The Brooks Ar-Met Rotameter with Mag/Na/Vue indicating extension is shown . . . however, Ar-Met meters are also available with six other alarm and transmission extensions, both electrical and pneumatic. WRITE FOR BULLETIN 130

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A complete line . . .
BROOKS ROTAMETERS
. . . for every service
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Howard L. Malakoff has been elected vice president and general manager, Cities Service Research and Development. He had served since 1956 as manager, Development Department, Petroleum Chemicals, a firm jointly owned by Cities Service and Continental Oil. Malakoff first joined the organization in 1943, with Cities Service Oil in Delaware. A native of Pittsburgh, he graduated from Carnegie Institute of Technology and for four years, till 1941, was a Teaching Fellow and instructor there.

Austin W. Fisher, Jr. has been named vice president and director of research of Ludlow Papers, Needham Heights, Mass. Fisher, who received his PhD from MIT, has been associated with Arthur D. Little for the past thirteen years.

Russell Bauer moves up to the post of vice president for manufacturing at Mead Johnson and Company. Formerly chief engineer for the Indiana firm, Bauer takes over responsibility for all domestic engineering and manufacturing activities. Bauer, who joined Mead Johnson five years ago, has been a guest lecturer at Washington University, the University of Missouri, and Missouri School of Mines.

W. J. Rossi has been appointed to the position of senior engineer in the Invention Development Division, Patent Department, San Francisco.

Paul T. Atteridg has been appointed manager, Refinery Plans Division, M. W. Kellogg. He will head a group of specialists who aid the company's refinery and petrochemical clients in planning new processing installations in the Western Hemisphere.

L. I. Griffin, Jr. has been named assistant director of the Esso Research Laboratories, Baton Rouge, La. In other changes at the Lab, **W. W. Boisture,** moves into the new position of personnel and business manager,

continued on page 170

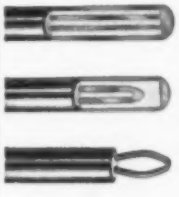
SERV-RITE®

Premium Sheathed Thermocouples
(.020" to .500" O.D.)

Problems of space limitation, temperature, or pressure are solved with SERV-RITE *premium* sheathed thermocouple wire. For maximum sensitivity, accuracy and quick response, SERV-RITE will furnish the best service for your dollar.

Featuring hard-pack insulation with heavy wall construction, SERV-RITE is fully flexible and can be bent to suit requirements. In addition to a choice of junction tips, fittings and connectors, SERV-RITE *premium* sheathed wire is available in a wide range of sheath materials, bright annealed. Standard and special thermocouples are made to suit any need.

All wires used in SERV-RITE *premium* sheathed thermocouple wire are selected and matched to conform to "Special" limits of error as set forth by I.S.A. Recommended Practice, R.P. 1.3. This wire meets the strictest over-all specifications.



Ask for
BULLETIN 1200-4
for complete details, ordering data, and prices on SERV-RITE *premium* sheathed thermocouple wires and accessories.

SERV-RITE *premium* sheathed thermocouple wire is manufactured exclusively by Pyro Electric Company.

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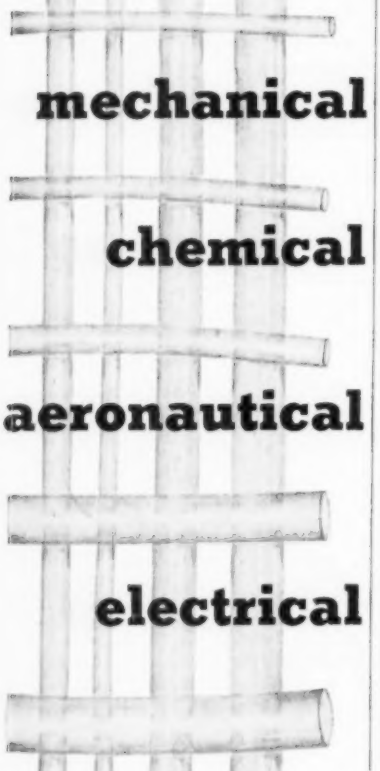
TEFLON TUBING



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For toughness and flexibility over the wide range of —90°C to 250°C, as well as chemical inertness, nonflammability, abrasion resistance, zero moisture absorption—and of course superior electricals—you know to choose TEFLON* tubing. And for precision manufacturing and inspection, Teflon and other tubings bearing the FLEXITE label conform to Markel's high standards of excellence. Ask for samples.

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1 SOURCE for EXCELLENCE in *Insulating Tubings, Sleevings, and Lead Wire*

NORRISTOWN, PENNSYLVANIA

For more information, circle No. 91

people

from page 169

Samuel A. Abrahams has been appointed by the United Nations to serve as magnesium resources expert on a three months' technical assistance mission to Israel. This appointment follows a preliminary survey made in 1955 when he served as adviser to the Israeli government. A consulting engineer in San Francisco, Abrahams is also executive vice president and general manager of Terminix of Northern California.

J. Charles Forman has completed the requirements for a PhD in chemical engineering at Northwestern University, and rejoined the staff of Abbott Laboratories, North Chicago, Illinois.

Joseph A. Palermo, University of Toledo, has been promoted to professor of Chemical Engineering. **Kenneth Fraser Gordon** becomes associate professor at the University of Michigan.

Marketing

B. J. Ferro has been appointed Western Sales Manager, Process Equipment Division, Air Products. He will have offices in Los Angeles. Ferro, before taking over this post, was manager of gas and petroleum sales for the company, and was closely identified with the new Bureau of Mines helium extraction facility at Keyes, Oklahoma.

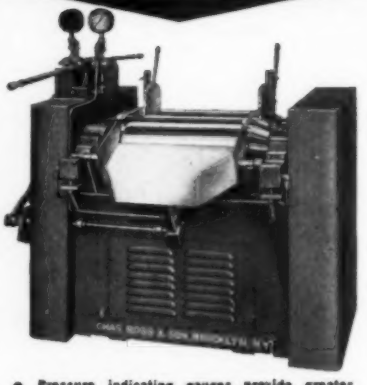
O. R. (Rudy) Matzner takes over the post of technical sales manager for Louis De Markus Corporation. He will handle application engineering, technical service and equipment sales for the Buffalo firm.

Stanley W. Cairns has been promoted to district sales manager, Jefferson Chemical Philadelphia District, with headquarters in New York City. Cairns has been with the company since 1952 as a salesman in New York State. In addition to a BS in chemical engineering from Princeton, he also studied business administration at Alexander Hamilton Institute.

Necrology

Russell Otto Hubbard, 47. Hubbard was superintendent of the Cellulose Esters Development and Control Department of Tennessee Eastman, a position he had held for over a year. He first came to Eastman in 1937, shortly after graduating from the University of Michigan, and remained with the company ever since. He was active in A.I.Ch.E., and held the position of director of the East Tennessee Section.

NEW Ross HIGH SPEED THREE ROLL MILLS WITH— ONE POINT HYDRAULIC ROLL ADJUSTMENT



- Pressure indicating gauges provide greater ease in properly setting rolls, and less skill or experience is required by operator.
- Roll pressure settings can be recorded for exact reproduction of material assuring standardization of product.
- Special equalizers assure positive parallelism of roll faces at all times for uniform dispersions and minimum maintenance costs.
- Mills have quick roll release with safety overload feature, and are convertible for either fixed or floating center roll operation. 2½x5, 4½x10, 6x14, 9x24, 12x30, 14x32, and 16x40" sizes.

Production size dispersion type Change Can Mixers with— DOUBLE PLANETARY stirrer action.

- Stirrers with special blade angles and very close clearances revolve on their own axis and also around can, developing 12 intense compressive and shearing actions with each revolution to break down and disperse agglomerates.
- Variable speed for infinite range of stirrer speed control. • Simplified vertical hydraulic lift for greatest ease in cleaning down stirrers. • Non-revolving can is completely enclosed during mixing for safety and to reduce solvent loss. Cans can be jacketed or fitted with slide gate when required. Cans are easily positioned or removed from Mixer.
- Extra heavy construction and standard type motor eliminate costly downtime. Oversized motor drives can be provided for kneading and mixing extremely heavy materials. 1, 2, 3, 4, 6, 8, 12, 25, 50, 65, 85, 125 and 150 gallon sizes.

Area of can contacted by stirrers during only one revolution of stirrers around can (2 seconds). Position of stirrers advances 4½° with each successive revolution to sweep entire area and all points on sides of can. Stirrers overlap each other as well as center of can.

Write for further information!

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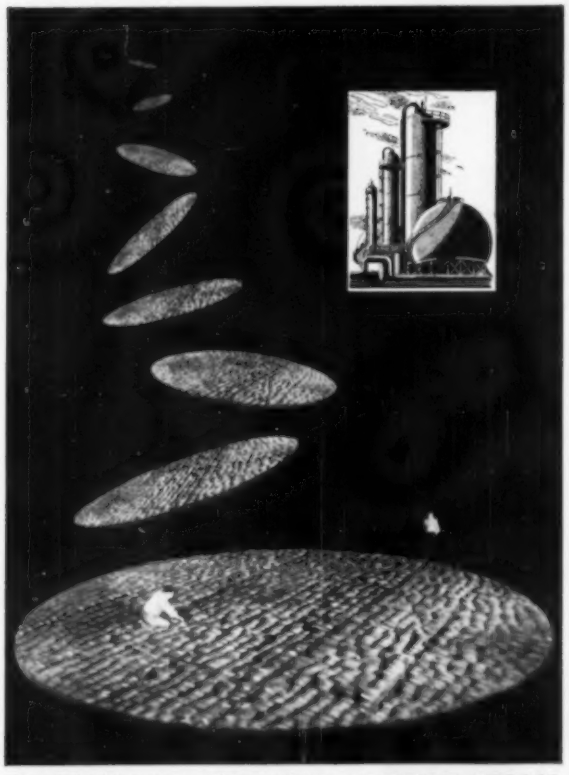
Brooklyn 5, N. Y., U. S. A.

For more information, circle No. 39

No liquid carry-over problem is ever too great for METEX!

In installation after installation...in all types of processing equipment—Metex mist eliminators are knocking back liquid entrainment...upping production...improving quality...cutting operating and maintenance costs. Your particular entrainment problem is no exception. For at Metal Textile we've been knitting low-cost answers to such problems since 1943. As the originators of knitted wire entrainment separators, Metal Textile has the engineering experience—and the research and production resources necessary to support that experience—to take on even the most difficult liquid entrainment problems. Our engineering department stands ready to help you solve your particular problems with complete design assistance. For latest design guides, write or call for Bulletin ME-9: Metal Textile Corporation, Roselle, N. J.



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...world's largest and oldest producer of knitted wire products
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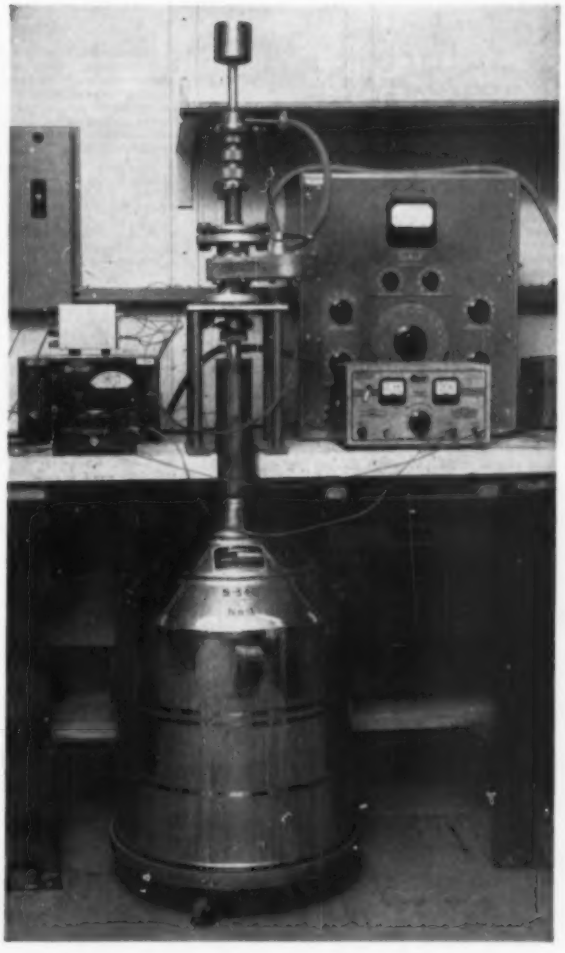

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The helium container shown above is in an industrial research laboratory experimental set-up for obtaining data at liquid helium temperature.

These standard helium dewars are available in capacities from 5 to 100 liters. Also available in sizes and shapes to meet special requirements.
Complete details on request.

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manufacturers of production and storage equipment for gaseous or liquid oxygen, nitrogen, air, hydrogen and helium

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future meetings

1960—MEETINGS—A.I.Ch.E.

● Mexico City, Mex., June 19-22, 1960. Hotel Del Prado. **Joint Meeting with Instituto Mexicano de Ingenieros Quimicos** — Tech. Prog. Chmn.: G. E. Montes, Northern Nat. Gas Co., 2223 Dodge St., Omaha 1, Nebr. **Petroleum & Natural Gas Processing in Latin America**—F. W. Jessen, Petrol. Eng. Dept., U. of Texas, Austin, Tex. & F. Corcuera, Ref. Madero, Tampa, Mex. **Chem. Engineering in Latin America**—G. Mayurnik, W. R. Grace, 3 Hanover Sq., New York 4, N. Y. & S. Vasan, Chem. Constr. Corp., 525 W. 43 St., New York 36, N. Y. **Chemical Engineering Education in the Americas**—W. R. Marshall, Jr., Dean, U. of Wisconsin, Madison 6, Wisc. & P. G. Roel, Inst. Tec. y de Estudios Sup. Sucursal de Correa J. Monterrey, Nuevo Leon. **Machine Computation-Optimization, Pitfalls, and Potentials**—W. M. Carlson, Louviers Bldg., Dupont, Wilmington 98, Del. **Distillation Equipment**—E. Katzen, 3732 Dogwood Lane, Cincinnati, O. & P. Ocampo, PEMEX, Vallarta #7-4° Piso, Mex., D. F. **Minerals and Metals**—D. B. Coghlan, Foote Mineral Co., Box 576, Berwyn, Pa. **Transfer Processes in Two-Phase Systems**—S. G. Bankoff, Ch.E. Dept., Northwestern U., Evanston, Ill. & A. Hoyos, Xola #1253-2° Piso, Mex., D. F. **Construction and Operating Costs for Latin American Projects**—R. Voorhees, Union Carbide Dev. Co., 30 E. 42 St., N. Y. 17, N. Y. & R. Pardo, Dir. Bufete Ind., Insurgentes sur 132-102, Mex., D. F. **Laboratory and Pilot Plant Techniques**—J. T. Cumming, Penn College, Cleveland 15, O. & M. Puebla, Inst. Mex. de Invest. Tec., Calzada Legaria #694, Mex., D. H. **Cryogenic Engineering**—F. Kurata, Ch.E. Dept., U. of Kansas, Lawrence, Kan. **Selected Papers**—J. A. Samaniego, Shell Dev. Co., Emeryville 3, Calif. **Financing International Projects**—P. F. Genachte, Chase-Manhattan Bank, New York, N. Y. & J. Horcasitas, Credito Bursatil, Isabel la Catolica #38, Mex., D. F. **Student Program**—J. J. McKetta, Ch.E. Dept., U. of Texas, Austin, Tex. See p. 146.

● Moscow, USSR, June, 1960. 1st Congress of International Fed., Automatic Control. To cover areas of **Theory, Hardware & Applications of Automatic Control**, U. S. participation sponsored by American Automatic Control Council. Affiliated societies: **A.I.Ch.E., ASME, AIEE, IRE, ISA.** A.I.Ch.E. Chmn.: D. M. Boyd, Universal Oil Prods., Des Plaines, Ill.

● Buffalo, N. Y., Aug. 14-17, 1960. Statler Hilton Hotel. **4th National Heat Transfer Conference & Exhibit. Sponsored by A.I.Ch.E. & ASME.** A.I.Ch.E. papers to S. W. Churchill, U. of Mich., Ann Arbor, Mich. ASME papers to J. P. Hartnett, U. of Minnesota, Minneapolis, Minn. Exhibit info to P. A. Joculvar, A.I.Ch.E., 25 West 45 St., N. Y. 36, N. Y.

● Boston, Mass. Sept. 7-9, 1960 M.I.T. **Joint Automatic Control Conference.** Sponsored by A.I.Ch.E., AIEE, IRE, ASME. For A.I.Ch.E. info refer to: W. H. Abraham, Eng. Exp. Sta., Dupont, Wilmington, 98, Del.

● Tulsa, Okla., Sept. 25-28, 1960. Hotel Mayo. **A.I.Ch.E. National Meeting.** Tech. Prog. Chmn.: K. H. Hachmuth, Phillips Petroleum Co., Bartlesville, Okla. **Multiphase Flow in the Production & Drilling of Oil Wells**—L. P. Whorton, Atlantic Refining, Box 2819, Dallas 1, Texas. **Natural Gas & Natural Gas Liquids**—R. L. Huntington, U. of Oklahoma, Norman, Okla. **Advances in Refinery Technology**—W. C. Offutt, Gulf R&D Co., P. O. Drawer 2038, Pittsburgh 30, Pa. **Petrochemicals**—C. V. Foster, Continental Oil Co., Ponca City, Okla. & H. L. Hays, Phillips Chem. Co., Bartlesville, Okla. **Piloting or Why Buy the Restaurant When All You Need is a Meal**—R. E. Weis, Phillips Pet. Co., Bartlesville, Okla. & D. Popovac, Continental Oil Co., Ponca City, Okla. **Corrosion & Materials of Construction**—W. A. Luce, The Duriron Co., P.O. Box 1019, Dayton 1, O., & M. S. Whorley, Black, Sivalls & Bryson, P.O. Box 1714, Oklahoma City, Okla. **Statistics and Numerical Methods Applied to Engineering**—R. L. Heiny, 2709 Jefferson, Midland, Mich. **Air & Ammonia Plant Safety**—G. Weigers, Amer. Cyanamid Co., P.O. Box 10008, Jefferson Branch, New Orleans 21, La. **Refinery & Natural Gasoline Plant Safety**—J. N. Romine, Phillips Petrol., Bartlesville, Okla. **Processing Agricultural Products**—A. Rose, Tex. Eng. Exp. Sta., Tex. A&M. Coll. Sta., Tex. **Chemical Reactions Induced or Modified by Radiation**—J. J. Martin, Ch.E. Dept., U. of Mich., Ann Arbor Mich. **Conservation & Utilization of Water**—F. J. Lockhart, Ch.E. Dept., U. of So. Cal., 3551 University Ave., Los Angeles 7, Cal. **Foams**—C. B. Grove, Jr., Syracuse U., Syracuse 10, N. Y. & R. L. Tuve, U.S. Naval Rsch. Lab., Wash. 25, D.C. **Computers as a Management Tool**—R. Cziner, Grace Chem. Co., 3 Hanover Square, New York 4, N. Y. **Non-Newtonian Fluid Mechanics**—A. B. Metzner, U. of Delaware, Newark, Del. **Student Program. Selected Papers**—R. H. Perry, Ch.E. Dept., U. of Oklahoma, Norman, Okla.
Deadline for papers: May 2, 1960.

● Washington, D.C., Dec. 4-7, 1960. Statler Hotel. **A.I.Ch.E. Annual Meeting.** Tech. Prog. Chmn.: D. O. Myatt, Science Communication, Inc., 1079 Wisconsin Ave., N.W., Wash. 7, D.C. **Air Pollution**—A. J. Teller, U. of Florida, Gainesville, Fla. **Unsteady—State Instrumentation**—T. J. Williams, Monsanto, Chem. Co., St. Louis, Mo. **Fluid Dynamics**—A. C. Acrivos, U. of California, Berkeley, Calif. **Information & Communications**—D. E. Gray, NSF, Wash. D.C. **Nuclear Reactor Operations**—R. L. Cummings, Atomics International, Canoga Park, Calif. **Nuclear Chemical Plant Safety**—C. E. Dryden, Ohio State U., Columbus, O. **Phase Transitions**—G. Bankoff, Northwestern U., Evanston, Ill. **Sales Overseas**—J. Costigan, The Sharpless Corp., 501 Fifth Ave., New York 17, N.Y. **Chemical Engineering—A Vital Link in Broadening the Uses of Agricultural Crops**—J. E. Simpson, U.S.D.A. **Chemical Warfare-Dispersal of Materials in Aerosol Form**—L. E. Garono, Army Chem. Corps. **Role of the Chemical Engineer in Environmental Health Engineering**—W. L. Faith, Air Pollution Foundation, 2556 Mission St., San Marino, Calif. **Feeding, Clothing, and Protecting the Combat Soldier**—Leo Spano, Quartermaster R&Eng. Command, Natick, Mass. **Phenomena Affecting Materials in Extreme Environments**—J. Hearne, Air Force R&Eng. **Impact of Govt. Programs on Chemical Engineering Education**—W. K. Davis, Bechtel Corp. **Toxic Plant Construction**—L. E. Garono, Army Chem. Corps. **Potentialities of Fuel Cells as Power Sources**—P. Greer, Army OOR. **Saline Water Conversions**—J. J. Strobel, OSW, Dept. Int. **Chemical Engineering in the Mineral Industry**—H. Perry, Chf. Bit. Coal Res. Br., U.S. BuMines. **Missiles & Rockets**—W. E. Sheehan, DDRE. **Economic Evaluation of New Processes**—J. H. Hirsch, Gulf R&D Co., P.O. Drawer 2038, Pittsburgh 30, Pa. **Heat Transfer**—S.

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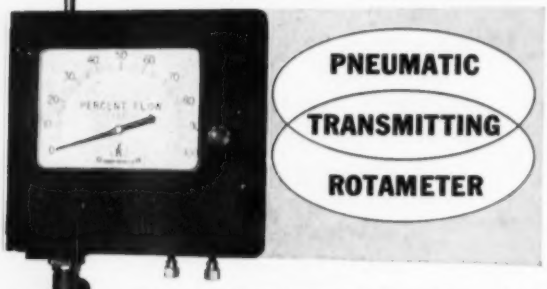

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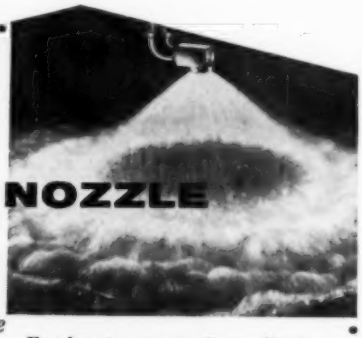

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W. Churchill, Ch.E. Dept., Michigan U., Ann Arbor, Mich. **New Crystallization Techniques**—H. M. Schoen, American Cyanamid Co., 1937 W. Main St., Stamford, Conn.
Deadline for papers: July 5, 1960.

1960—MEETINGS—NON-A.I.Ch.E.

● San Francisco, Calif. Apr. 18-20, 1960. Mark Hopkins Hotel. **Symposium on Chemical Reactions in the Lower and Upper Atmosphere** sponsored by Stanford Research Inst. For info: R. D. Cadle, SRI, Menlo Park, Calif.

● Palo Alto, Calif. Apr. 25-26, 1960. **The Combustion Institute**, sponsored by Lockheed. For info: A. L. Berlad, Convair Sci. Res. Lab., 5001 Kearney Villa Rd., San Diego 11, Calif.

1961—MEETINGS—A.I.Ch.E.

● New Orleans, La., Feb. 26-Mar. 1, 1961. Hotel Roosevelt. **A.I.Ch.E. National Meeting.** Tech. Prog. Chmn.: A. L. Regnier, Petroleum Chem., P.O. Box 6, New Orleans 6, La. **Brainstorming Technical Problems**—G. C. Szego, Space Technology Labs., P.O. Box 95001, Los Angeles 45, Calif. **Kinetics of Catalytic Reactions**—M. Boudart, Princeton U., Princeton, N.J. **Petrochemicals—Future of the Industry on the Gulf Coast**—J. A. Sherred, Monsanto Chem. Co., St. Louis 66, Mo. **Filtration**—F. M. Tiller, U. of Houston, Houston, Texas. **Settling**—A. G. Keller, La. State U., Baton Rouge, La. **Future Processing Technology in the Petroleum Industry**—A. P. Kaulakis, Process Res. Div., ESSO. **Education and Professionalism**—R. P. Dinsmore, Goodyear Tire & Rubber Co., Akron 16, O. **Mathematics in Chemical Engineering**—R. L. McIntire, Mathematical Eng. Assoc., 3108 Sweetbriar, Fort Worth 9, Tex. **Evaluation of R&D Projects**—L. A. Nicolai, 239 Parsonage Hill Rd., Short Hills, N.J. **Liquid—Liquid Extraction**—R. B. Beckman, Carnegie Tech., Pittsburgh 13, Pa. **New Petrochemical Processes in the Area**—B. G. Caldwell, Dow Chem. Co., Plaquemine, La. **Materials of Construction**—R. V. Jelinek, Syracuse U., Syracuse, N.Y. **Selected Papers**—E. Mannings, Shell Oil Co., Norco, La.
Deadline for papers: Sept. 5, 1960.

● Cleveland, O., May 7-10, 1961. Sheraton-Cleveland. **A.I.Ch.E. National Meeting.** Tech. Prog. Chmn.: R. P. Dinsmore, Goodyear Tire & Rubber Co., Akron 16, O. **Management Criteria for Capital Investment; Technical Phases of the Synthesis of Isoprene; Process Development of the New Synthetic Rubbers; Use of Radioactive Materials for Chemical Process Control; Modernized Processes for Heavy Chemical Manufacture; Optimum Utilization of Pilot Plant Facilities; Petrochemicals as The Starting Materials for High Polymers; Chemical Engineering and Metal Refining; Fluid Mechanics; Applications of Photography in Chemical Engineering.**
Deadline for papers: Dec. 7, 1960.

● Lake Placid, N. Y., Sept. 24-27, 1961. Lake Placid Club. **A.I.Ch.E. National Meeting.** Tech. Prog. Chmn.: E. R. Smoley, 30 School Lane, Scarsdale, N. Y. **Process Management; Commercial Chemical Development; Sales Engineering.**

● New York, N. Y., Dec. 3-6, 1961. Hotel New Yorker. **A.I.Ch.E. Annual Meeting.** Tech. Prog. Chmn.: A. V. Caselli, Shell Chem. Corp., 50 W. 50 St., N. Y. 20, N. Y. **Heat Transfer; Management; New Processes; Nuclear Engineering; Water Pollution; Process Dynamics; Pilot Plants; Fundamentals; Petroleum & Petrochemicals; Fluids; Fluidization; Sublimation; Adsorption; Student Program.**

1962—MEETINGS—A.I.Ch.E.

● Los Angeles, Calif., Feb. 4-7, 1962. Hotel Statler. **A.I.Ch.E. National Meeting.** Tech. Prog. Chmn.: G. C. Szego, Space Technology Labs. Inc., P.O. Box 95001, Los Angeles 45, Calif.

● Baltimore, Md., May 20-23, 1962. Lord Baltimore Hotel. **A.I.Ch.E. National Meeting.** Tech. Prog. Chmn.: G. L. Bridger, R&D Div., Washington Research Center, W. R. Grace, Clarkesville, Md.

● Denver, Colo. Sept. 16-19, 1962. Hotel Statler. **A.I.Ch.E. National Meeting.** Tech. Prog. Chmn.: P. H. Poettman, Ohio Oil Co., P.O. Box 269, Littleton, Colo.

Unscheduled Symposia

Correspondence on proposed papers is invited. Address communications to the Program Chairman listed with each symposium below.

continued on page 174

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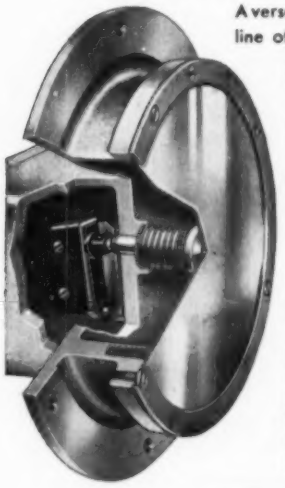

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future meetings

from page 173

Computers in Optimum Design of Process Equipment—Chen-Jung Huang, Dept. of Chem. Eng., Univ. of Houston, Cullen Blvd., Houston 4, Texas.

Solar Energy Research—J. A. Duffie, Director of Solar Energy Laboratory, Univ. of Wisconsin, Madison Wis.

Hydrometallurgy—Chemistry of Solvent Extraction: G. H. Beyer, Dept. of Chem. Eng., Univ. Mo., Columbus, Mo.

Process Dynamics as They Affect Automatic Control—D. M. Boyd, Universal Oil Prods., Des Plaines, Ill.

Drying—R. E. Peck, Ill. Inst. of Tech., 330 So. Federal, Chicago, Ill.

The Chemical Engineer's role in design and development of petroleum and petrochemical production facilities will be the core of the Petrochemical and Refining Exposition to be held in conjunction with the National A.I.Ch.E. Meeting in New Orleans, Feb. 26-Mar. 1, 1961.

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The following is a list of candidates for the designated grades of membership in A.I.Ch.E. recommended for election by the Committee on Admissions. These names are listed in accordance with Article III, Section 8 of the Constitution of A.I.Ch.E.

Objections to the election of any of these candidates from Members and Associate Members will receive careful consideration if received before April 15, 1960, at the office of the Secretary, A.I.Ch.E., 25 West 45th Street, New York 36, N. Y.

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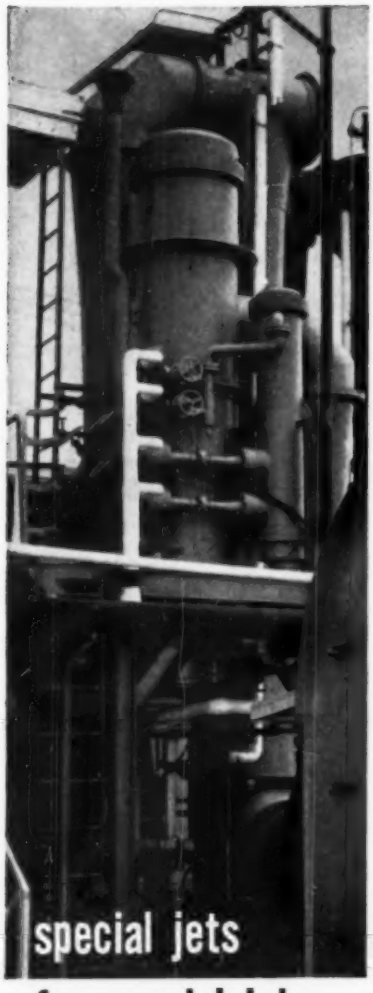

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Chemical engineers with broad technical background and desire for responsibility. Qualified men must be capable of assuming responsibility for engineering and design of chemical plants—from basic process calculations through equipment specifications and purchasing, preparation of construction drawings, and plant start-up.

Reply fully to: HENRY F. PETERS,
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The work encompasses translation of basic process information into plant design or modification for complex chemical plants. Qualities required:
Competence in process engineering acquired through extensive experience in commercial chemical developments. Imagination and insight in visualizing processing schemes. Experience in the economics of process and equipment choice. Familiarity with plant operations desirable. Sound educational background necessary in Ch. Eng.—advanced degree desirable.

Reply fully to: DR. JOHN H. LUTZ,
Director of Project Evaluation

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Graduate chemical engineer with extensive project experience in the design and construction of pertochemical plants, for responsible position with advancement possibilities in our project evaluation group. Experience necessary for application of judgment and experience in the explication of new projects and in the development of major sales efforts.

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CHEMICAL ENGINEERING TEACHING POSITIONS AVAILABLE

A list of chemical engineering teaching positions in schools and universities in the United States and Canada on Feb. 20, 1960 may be obtained from the Secretary, A.I.Ch.E., 25 West 45th Street, New York. Salary data and rank of position are given.

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Permanent position for Ph.D. in Chemical Engineering interested in teaching and research. Salary and rank commensurate with ability and background. Write Dean of the School of Engineering, Vanderbilt University, Nashville 5, Tenn.

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A.I.Ch.E. Members

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CHEMICAL ENGINEERING PROFESSOR—Desire consulting association full time during summer and part time during academic semesters. Eighteen years' experience in propulsion, heat transfer, nuclear engineering and technology, kinetics and catalysis, distillation, process development and engineering. Box 8-3.

ATTENTION CHEMICAL PLANT MANAGERS—My fifteen years' of varied experience in chemical engineering, covers operating temperatures from —300 to +2,000°F, operating pressures from 2 psia to 12,000 psia, coal, petroleum, natural gas, synthesis gas, fluid and fixed bed catalysts, pilot plant design, construction, and operation, organic and inorganic production from grams to hundreds of tons per day, tonnage oxygen, nuclear chemical processing, separation and purification processes for gases, liquids and solids. This unique and valuable experience is not being utilized in my present position. If you have a position in engineering or production which will allow me to realize my full abilities and ambitions, please write to Box 9-3.

CHEMICAL ENGINEER—Age 38, nine years' petrochemical and petroleum economics. Seven years' technical aid to production in petrochemical plant, and uranium isotope separation plant. Desire position with chemical company in south or midwest. Box 10-3.

CHEMICAL ENGINEER—B.Sc.Ch.E., age 31, veteran. Over six years' experience petroleum processing, project design, bench-scale pilot plant supervision. Desire technical service position. Prefer southern California. Box 11-3.

(continued on page 178)

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MS or PhD

1. To perform theoretical investigations of reaction processes and feasibility studies of new ideas. Requires a strong theoretical background in thermodynamics and kinetics with up to 3 years research experience.

2. To perform theoretical and experimental studies on solid state leading to unusual applications. Requires solid state experience or interest.

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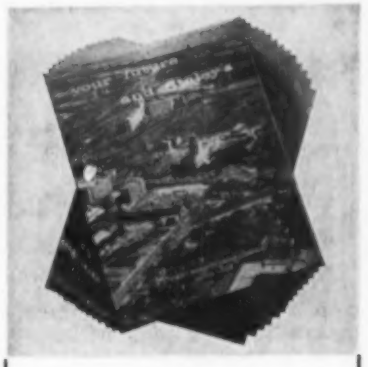

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with several years experience relating to electrolytic chlorine-caustic operations. Work assignments will also include organic chlorinations.

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preferably Chemical Engineer with 2-5 years experience in petrochemical operation or related industry.

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preferably between ages 32 and 40 and a technical graduate in mechanical, civil or industrial engineering, with approximately 10 years experience in planning, scheduling and control of chemical plant maintenance.

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Dr. Bruce D. Gleissner

FRONTIER CHEMICAL COMPANY

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SOLVAY PROCESS DIVISION
ALLIED CHEMICAL CORP.
P. O. Box 271
Syracuse 1, New York

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Ethyl Corporation
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Ferndale 20, Michigan

SITUATIONS WANTED
A.I.Ch.E. Members

(continued from page 176)

B.S.Ch.E.—Age 30, experience in patents, application preparation and prosecution; knowledge of organic chemistry including polymers; Desire patent position, technical writing, industrial sales, location immaterial. Box 12-3.

BRAZIL — CHEMICAL ENGINEER — Eleven years' experience Latin America and U.S. in petroleum refining, petrochemicals covering process engineering, manufacturing planning and analysis, technical service. B.S. 1948, U.S. citizen, fluent Portugese and Spanish. Seek challenging position in new or expanding operation. Box 13-3.

CHEMICAL ENGINEER—M.S.Ch.E. 1955. Age 31, single. Diversified background. Desire design or development, will consider other challenging opportunities. Will travel, relocate. Box 14-3.

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RESEARCH DIRECTOR—B.S.Ch.E. 1942. Age 38. Twelve years' diversified experience in heardboard research and development. Looking for challenging position as Research or Technical Director of progressive company in southeast or southwest. $12,000. Box 16-3.

CHEMICAL ENGINEER—B.S.Ch.E., 1957. Age 24, family. Three years' experience process engineering. Desire challenging position in the Kansas City or St. Louis area. Box 17-3.

CHEMICAL ENGINEER — M.S.Ch.E. (1949), P.E. Age 34. Ten years' experience includes process design, control and development, works engineering, planning and scheduling, in nuclear power, explosives, acids, fermentation. "Q" clearance. Desire responsible position in process or project engineering. Prefer West Coast location, will consider others. Box 18-3.

CHEMICAL ENGINEERING UNIVERSITY PROFESSOR—Ten years' of university research, teaching, and administration. Honors, publications. Seek new challenging twelve month university position. Available: Summer—1960. Box 19-3.

continued on page 180

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Ph.D or equivalent; 5-10 years experience. Research on adhesives and adhesive application.

BS or MS; 0-6 years experience. Research in resin chemistry and on problems involving adhesives and adhesion.

BS or MS; 0-6 years experience. Research in carbohydrate and cellulose chemistry.

Wood Technology

BS or MS; 0-6 years experience. Research on wood fiber, fiber board and other fiber products.

Drafting

BS; 0-6 years experience. Architectural drafting, particularly detailed drawing of structural elements.

Market Research

Advanced degree either in a technical field or in economics with training in the other; 5-10 years experience. For responsible position as market analyst to guide planning and execution of research studies.

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The manufacturing technical service department of our large petrochemical plant at Houston, Texas, has an opportunity for a well qualified chemical engineer, B.S. or M.S., with five to eight years experience in process development and improvement studies. Processes include those for manufacture of Ethyl and Methyl Acrylate, Acetone Cyanohydrin, Ethylene Cyanohydrin, etc., in modern continuous and highly instrumented facilities.

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Liberal relocation allowance for you and your family.

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A.I.Ch.E. Members

(continued from page 178)

CHEMICAL ENGINEER—B.S. Experience: three years' physical test laboratory, five years' test engineer spray dryer manufacturer, eight years' plant engineer inorganic chemical plant. Solved production problems in pumping, mixing, filtering, heat transfer, air handling, scrubbing, revamping equipment and maintenance. Box 21-3.

PROCESS ENGINEER—B.Ch.E. 1954, imaginative and intelligent, seek responsible and challenging position in process design or process development. Five years' experience in development, project engineering and process design in low temperature gas separation. Present salary $8,900. Box 22-3.

SUCCESSFUL PLANT MANAGER—Nationally known chemical specialties company seek advancement. Chemical Engineer with twenty years' experience in every phase of chemical business. Does your business need a capable President or Executive Vice President? Box 23-3.

CHEMICAL ENGINEER—B.S., twelve years' diversified experience, applied research, engineering, technical service, quality control. Fertilizer specialist. Practical and business minded accept responsible management position only. Prefer small midwest or midsouth company. Box 24-3.

SALES ENGINEER—B.S.Ch.E., age 27, married. Two years' experience in sales of capital equipment. Desire sales position in Philadelphia, Pa. area. Box 26-3.

PROJECT ENGINEER—B.S.Ch.E., P.E., age 31, veteran, family. Experienced in economic evaluations, proposals, design, specs, construction and start-up. Desire project engineering with opportunity to advance into engineering management. Minimum $9,600. 38. Box 27-3.

EXPERIENCED CHEMICAL ENGINEER AND MANAGER—Ability to handle variety of assignments proven in eighteen year career with engineering company. Strong background in process design, project management and plant startup. Qualified for high level engineering position. B.S.Ch.E., age 38. Box 28-3.

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(continued on page 182)

ENGINEERING SOCIETIES PERSONNEL SERVICE, INC.

(Agency)

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These items are listings of the Engineering Societies Personnel Service, Inc. This Service, which cooperates with the national societies of Chemical, Civil, Electrical, Mechanical, Mining, Metallurgical and Petroleum Engineers, is available to all engineers, members and non-members, and is operated on a nonprofit basis. If you are interested in any of these listings, and are not registered, you may apply by letter or resume and mail to the office nearest your place of residence, with the understanding that should you secure a position as a result of these listings you will pay the regular employment fee of 5% of the first year's salary if a non-member, or 4% if a member. Also, that you will agree to sign our placement fee agreement which will be mailed to you immediately, by our office, after receiving your application. In sending applications be sure to list the key and job number.

When making application for a position include eight cents in stamps for forwarding application to the employer and for returning when possible.

A weekly bulletin of engineering positions open is available at a subscription rate of $3.50 per quarter or $12 per annum for members, $4.50 per quarter or $14 per annum for non-members, payable in advance.

Positions Available

New York Office

CHIEF ENGINEER, graduate mechanical, chemical or electrical, with Master's in instrumentation and control desirable; experience in systems engineering in instrumentation manufacturing, application engineering, sales management and supervisory background desirable. Will design and apply instrumentation systems for power and process applications; act as liaison agent with companies manufacturing systems; supervise estimating and service department, etc. Salary, $10,000 a year plus profit participation. Location, New York, N. Y. W8656.

CHEMICAL ENGINEERS. (a) Chemical Process Engineer with 3 to 10 years' experience in fluid and solid handling for a large project. Experience in consulting engineering office on petro-chemical plants very desirable; such as Kellogg and Lummus. Salary, $10,000-$13,000 a year. (b) Chemical Pilot Plant Engineer to head up process engineering, plan experiments, tests, etc. for continuous plant operation. Salary, $10,000-$15,000 a year. Location, Midwest. W8650.

TEST ENGINEERS, degree in chemical engineering, plus up to 3 years' experience, to analyze, set up and supervise the conducting of tests for customers or for development work on any equipment and make design or process recommendations resulting therefrom. Conduct tests in the field, handle internal inquires on test applications, maintain close cooperation with sales and application engineering departments. Apply by letter including complete resume and salary requirements. Location, upstate New York. W8644.

LABORATORY ENGINEER, metallurgical, non-metallic or inorganic chemical engineer, to set up laboratory, select equipment and procedures of a chemical and physical laboratory for quality control and production research. Salary open. Location, Texas. W8643.

PROCESS ENGINEER, graduate chemical, with 5 to 10 years' experience in the supervision of the production of tungsten from ore. Salary open. Location, northern New Jersey. W8633(a).

STAFF ENGINEER, mechanical or chemical engineering graduate, with 3 to 5 years' food processing equipment experience. Salary, about $8000 a year. Location, New York, N. Y. W8627.

TECHNICAL WRITERS, graduate electrical, mechanical or chemical engineers, with some administrative ability or interest in writing. Should have worked on editorial staff or with consulting firms writing proposals or having done some technical writing. Will consider young engineers who have worked on college year book or newspapers. Salaries open. Location, Illinois. W8611.

CHEMICAL ENGINEERS, B.S. or M.S., with up to 5 or 8 years' experience in the petrochemical industry, primarily in the area of process engineering and design. One or two openings at the Ph.D. level with none to 3 years' experience. Excellent opportunities. Salaries open. Location, Pennsylvania. W8562(b).

CHEMICAL ENGINEER, graduate, with one to 5 years' experience in the petroleum refining or chemical field doing research. Salary, $6000-$7200 a year. Location, New York, N. Y. W8531.

PRODUCTION ENGINEER, chemical or mechanical engineering graduate, with plant engineering, process or production experience in pharmaceutical fields including packaging and materials handling. Some traveling. Salary, $7000-$8000 a year. Location, New Jersey. W8523.

DEVELOPMENT ENGINEER, graduate chemical, with 2 to 5 years' experience, to work on improving methods of manufacturing plastic films for flexible packaging. Location, Iowa. W8507.

PACKAGING ENGINEERS, graduate chemical or mechanical, with 5 to 10 years' experience in films, packaging or packaging machinery, to conduct packaging evaluations of new films in the field. Must have dependability and maturity to operate with minimum of supervision. Travel about 50% of time from headquarters. Headquarters, Massachusetts. W8506.

CHEMICAL ENGINEER, graduate, with about 5 years' production experience in nonferrous smelting and refining fields. Salary, $8000 a year. Location, New England. W8427(a).

RESEARCH PROCESS ENGINEER, degree in chemical engineering; will consider man with from none to 10 years' experience, for company manufacturing cellulose. Location, New Jersey. W8416.

JUNIOR PROCESS ENGINEER, graduate chemical engineer, with experience, to assure production quality, maintain production specifications, investigate customer complaints and general implementing of transfer of new products from research, development to production. Company manufactures industrial plastics. Salary, $6000-$6500 a year. Company will pay placement fee. Location, Delaware. W8405.

Chicago Office

RESEARCH ENGINEERS, B.S. to Ph.D. in Chemical Engineering. Positions involve carrying out engineering projects from laboratory stage to full commercial development including preliminary, intermediate and final cost estimates, design and operation of the Pilot Plant. Company manufactures food products. Salaries range from $6500 to $12,000 a year depending on education and experience. Employer will pay placement fee. Location, Illinois. C7893.

San Francisco Office

RESEARCH AND DEVELOPMENT ASSISTANT, graduate chemical engineer, either a recent graduate or with a few years' experience. Will assist head of research department in making extensive and detailed reports on all phases of sugar processing and usage, for a manufacturer. Salary, $6000 a year for recent graduate; better for experienced man. Location, Sacramento Valley. SJ-5082-R.

CHEMICAL ENGINEER, graduate, under 50, with substantial experience of several years' in fossil fuels, petro-chemicals or coal research. Capable of carrying on responsible work with minimum of supervision. Primarily concerned with coal research in connection with expansion in steam electric generating facilities; could involve any other investigation in which research department may become involved. Salary, $7200 a year for minimum qualifications; $9600-$10,800 a year for exceptionally qualified man, plus fringe benefits. Position is with a public utility. Location, Pacific Northwest. SJ-5081-R.

SENIOR RESEARCH CHEMIST, B.S. or M.S. in chemical engineering, with a minimum of ten years' experience and proven record of development in precision molded rubber products. Compounding experience should include extensive development work at senior level in rubber and synthetic rubber materials and bonding or rubber to metal. Experience should further include production problems or rubber molded products. Will carry out applied research as directed. Location, San Francisco Peninsula. SJ-5075-R.

SALES ENGINEER, chemical, electrical, mechanical or petroleum graduate, 23-35. After three months' training period, will sell temperature, pressure, flow, liquid level, etc., type of instruments for measurement and control of such factors to process industries, process equipment manufacturers and contractors (pulp and paper mills, petro-chemical, chemical, food processing and preserving, sugar and rubber manufacturers, refrigeration, air conditioning, milk products process). Salary, $6300-$6900 a year plus expenses. Must have car. Location, Oregon and western Idaho. SJ-5067.

PRODUCT DESIGNER, chemical or mechanical graduate, young, able to direct plastics engineering with design and supervisory experience preferred in plastics and rubber, for a job shop operation. Salary open. New and growing division of large company. Location, southern California. SJ-5057(b).

RESEARCH ENGINEER, graduate chemical, well qualified by past experience as a product developer for a manufacturer, preferably in fibrous products technology. Will deal with agricultural products technology. Will deal with vegetable and wood fibers extensively and should have a capability of combining and processing. Will work on development of new type of particle or building board for new company. Salary, about $8000 a year. Location, Eureka, Cal. SJ-5052.

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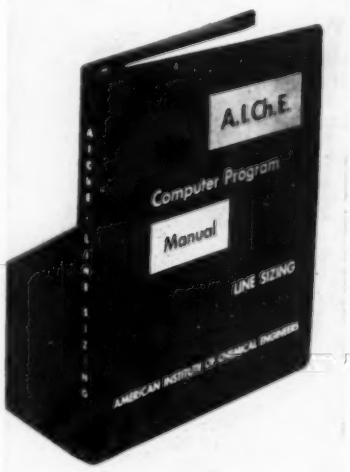

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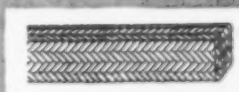

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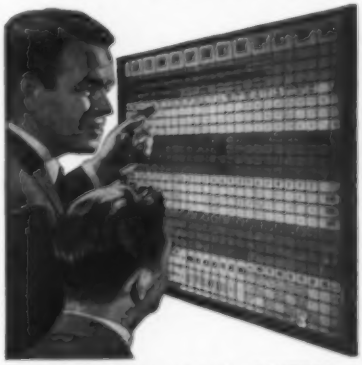

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News and Notes of A.I.Ch.E.

Speakers' list—Chuck Umholtz of the Humble Oil & Refining Company at Baytown, Texas, is heading a new activity of the Program group that should have the Local Section program officers drooling. The members of the new subcommittee of the Pro-

gram Committee have set out to develop a national-program speaker's group—which is quite different from the speakers' list which the Secretary's office has distributed to the Local Sections for a number of years. The present speakers' list evaluates the speakers who appear before Local Sections in terms of interest and effectiveness. The committee headed by Umholtz has extended this to an evaluation program for the four national A.I.Ch.E. technical meetings, and the presenting authors of the four best papers from each national meeting will be asked to participate in a program through which they may be solicited by A.I.Ch.E. Local Sections to present their papers at Local Section meetings, including the present very popular, all-day technical meeting. There is still groundwork to be done by the Umholtz group, but it has made preliminary selections, and Chuck will be in an excellent position to answer any questions.

Guidance activities—Almost all chemical engineers know of the work of the Career Guidance Committee of A.I.Ch.E.—this year under the direction of Tom Walsh. Many of the Local Sections cooperate closely with the A.I.Ch.E. Guidance Committee and also with the Guidance Committee of the Engineers' Council for Professional Development. This year the E.C.P.D. group has turned out an interesting memorandum on engineering guidance, which describes the two annual mailings sent by the E.C.P.D. to the country's 3,000 high schools to provide literature and to call the attention of the superintendents, principals, and counselors to the guidance services available to them from the E.C.P.D.'s state committees. F. J. Jeffers, Chairman of the E.C.P.D. Guidance Committee this year, is issuing a call for a large number of engineers to participate in E.C.P.D.'s coordinated guidance work through the Local Sections' career guidance committee. Sections that want to begin a program can get help from Tom Walsh (A.I.Ch.E.'s chairman) or F. J. Jeffers (chairman of E.C.P.D.'s committee, in care of the Baltimore Gas & Electric Company, Baltimore 3, Maryland). Jeffers has issued a directory of the chairmen of the regional guidance committees for E.C.P.D. Any member of A.I.Ch.E. interested in this activity in an area that does not have an A.I.Ch.E. Local Section should write to Walsh, Jeffers, or the Secretary of the Institute.

Roy F. Weston, for several years chairman of A.I.Ch.E.'s Committee on Pollution Control Engineering, has been reelected a trustee of the American Sanitary Engineering Intersociety Board for a three-year term.

New Engineers' Club—Another future section of A.I.Ch.E. appeared this past fall with the formation, by John C. Randall as organizing chairman, of a club in western North Carolina. The headquarters is Hendersonville, North Carolina, and any chemical engineers in that area who are interested should write to John Randall at 1941 Haywood Road, Hendersonville. The first meeting was held at the Ecusta Paper Division of Olin Mathieson Chemical Corporation.

Student participation—Jim Knudsen, retiring chairman of the Student Chapters Committee, provided an interesting statistic for members of A.I.Ch.E. in his annual report—76% of all fourth- and fifth-year students are members of a Student Chapter. This is a marked increase over prior years and attests to the vitality of the Student Chapters Committee's work and that of the Student Chapter Counselors.

Petrochemical show—A new A.I.Ch.E. activity of prime interest to those in the organic side of chemical engineering is the Petrochemical and Refining Exposition which A.I.Ch.E. will launch during the New Orleans meeting next February. Details of the meeting are still being worked out, but we expect to have, under the guidance of Al Regnier, an outstanding program for the refining and chemical end of the petroleum industry.

Student aid—Nathan Gilbert, Student Chapter Counselor at the University of Cincinnati, reports that he is using 500 copies of the reprints from *Chemical Engineering Progress* on dimensionless numbers in his chemical engineering courses.

Japanese anniversary—Shown here is the name of a society in Japan, the Society of Chemical Engineers. Recently we had a representative of the group in our office, Dr. Yagi, who

化学工学協会

issued an invitation to the A.I.Ch.E. to be represented at the Tenth Anniversary of the Japanese society, which will take place in November of 1961.

The top 10 (12)—Recently, as a matter of interest to national members, the Secretary tabulated the number of chemical engineering students graduating in '57, '58, and '59 who have joined the A.I.Ch.E. In an attempt to establish the first ten colleges leading in numbers of graduates who became members, it was found that three tied for tenth place; so the top ten have become a round dozen. In order, they are University of Texas, College of the City of New York, Brooklyn Polytech, Ohio State, Carnegie Tech, Rensselaer Polytech, M. I. T., Lehigh, University of Michigan, Missouri School of Mines, Newark College of Engineering, Purdue University.

F.J.V.A.

how to choose a dependable controlled volume pump

STUDY the specifications of a typical controlled volume pump and you can quickly judge its accuracy . . . corrosion resistance . . . even controllability. But you'll find no specifications for dependability or low maintenance, which may be far *more* important in determining a pump's usefulness.

Over the years Milton Roy has studied thousands of pumps, comparing design and construction with service records, in an attempt to pin down the characteristics that contribute most to dependable pumping. Most of these characteristics demand more time consuming methods of manufacture and more expensive materials than conventional designs. All of them have been incorporated into the standard Milton Roy pumps.

Alignment an absolute necessity

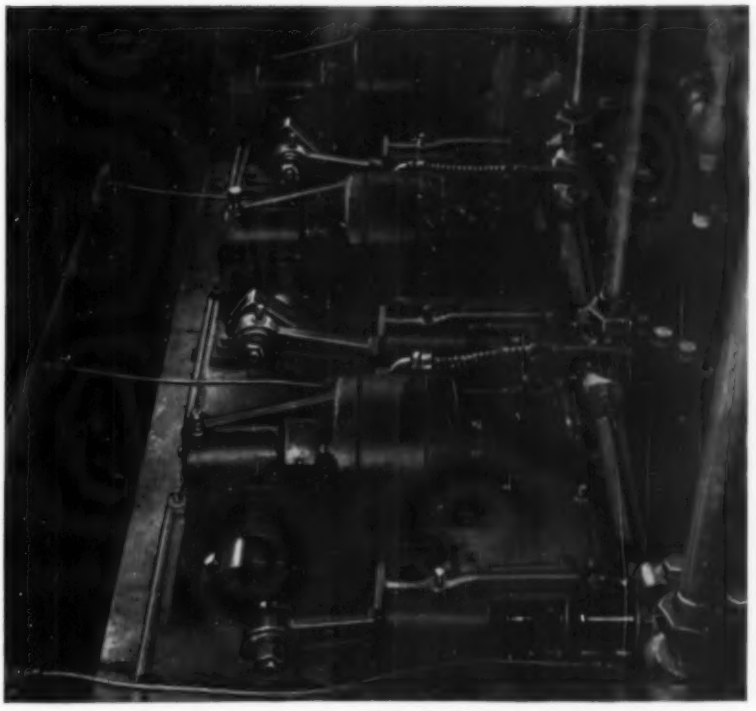
The pump base has more to do with good pump alignment than any other single part, yet its importance is rarely recognized by the pump buyer. Dependable pumping demands an extremely rigid and sturdy webbed base that positively resists deformation and prevents the misalignment that is sure to result. Base pads should be machined to eliminate the problems of aligning and protecting rough cast parts.

Massive pump frames are another necessary bulwark against distortion. Just as rigid bases keep motor, drive, and pump aligned, heavy pump frames keep plunger, packing, and liquid end in line. As a result, both packing and plunger wear more evenly and give longer service.

"Over-Engineering" assures longer life

Typical examples of how dependability must be built into a pump are the crank nuts. Conventional hardware often permits slight crank slippage . . . just enough to throw an undesirable strain on the pump drive. Substituting more expensive brass nuts boosts costs, but, since they can be drawn up tighter, eliminates the problem of slippage.

Other examples of "over-engineering" that extend pump life include generous bearing surfaces that far exceed permissible minimums . . . self lubricating connecting rod bearings . . . special gear tolerances that eliminate grinding wear, vibration, and noise . . . and high cross head length to diameter ratios to absorb unavoidable abuse without injury. Furthermore, the surface of the pump must be protected with a resistant coating as protection against corrosive fume and splash.



These three Milton Roy pumps have been feeding phosphate solution to the boilers of a major East Coast brewer for twelve uninterrupted years. Aside from periodic lubrication and examination, the total cost of parts replaced in that time is just $18.00 . . . twelve sets of packing.

The low cost of dependability

Obviously, a pump with features like these has to carry a higher price tag than one without. But the *cost* of dependable pumping is something else again. As the caption above illustrates, savings gained through years of dependable pumping with minimum maintenance expense far outweigh any slightly higher initial cost. There's little doubt that the more dependable pump always costs less in the long run.

If accurate precision metering of liquids is one of your problems, look again to the enviable reputation more than 75,000 Milton Roy pumps have established for dependable controlled volume pumping.

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